Does Globalization Cause Growth?

Quantifying Trade's Effect on Income

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Abstract

Economic theory predicts a positive effect of trade on income. Empirically, it is hard to estimate the causal effect of trade on income. This is so because more trade leads to higher incomes while at the same time richer countries trade more. One approach to circumvent this problem exploits the variation in trade due to countries' geography. First proposed by Frankel and Romer (1999), the strategy is to generate an instrumental variable for trade using a specification based on the gravity model of bilateral trade. This thesis explores the robustness and validity of this approach to changes in the geographic variation extracted from countries' trade.

The second chapter addresses the question: how much does the specification of the bilateral trade equation used to generate the instrument for trade, matter for the outcome that trade affects income positively? Instruments are generated using different specifications from the original set of explanatory variables and predicting across actual trading partners, so excluding out-of-sample predictions of bilateral trade flows from the instrument set. Subsequently, the results from using each instrument in the income regression are collated. On the one hand, the results are reassuring because they are robust to the different specifications. On the other hand, the results are puzzling precisely because they are robust to the use of instruments generated using a single covariate. This is inconsistent with the theoretical foundation that underlies the instrumentation strategy and raises the question what is actually driving these results.

The third chapter explores this question by focusing on the effect of the prediction method on the results. Using bilateral trade shares predicted from randomly generated geographical characteristics to form instruments for trade, chapter 3 shows that the results are highly sensitive to the prediction method used. The chapter demonstrates analytically and empirically that the coefficient of trade openness in income regressions is severely upward biased when out-of-sample predictions are excluded from the instrument set because the instrument captures the number of trading partners and, therefore, violates the exclusion restriction. Thus, out-

of-sample predictions should always be included in the instrument set to eliminate mechanical endogeneity.

Another prerequisite for the instrument's validity is that one controls for all other channels through which geography can affect income.The literature makes the case to include the channel of migration as it is also determined by geography. So in the fourth chapter, I expand on this by also including Foreign Direct Investment (FDI) in the income equation. Like trade and migration, FDI affects income and the literature finds that FDI flows can be explained by the gravity model and thus geography. From the results I cannot adequately identify the effect of trade, migration and FDI. One reason is the multicollinearity between the variables. The second reason is that by using the same instrumentation strategy for trade, migration and FDI, each instrument essentially captures the same variation. As a result, I cannot interpret the estimates that allow me to draw conclusions about the relative importance of trade, migration and FDI.

Thesis including published works declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes zero original papers published in peer reviewed journals and one submitted publication. The core theme of the thesis is 'Globalization and Growth'. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the Department of Economics under the supervision of Prof. Dr. Jakob B. Madsen and Dr. Laura Puzzello.

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

In the case of Chapter 3 my contribution to the work involved the following:

Thesis Chapter	**Publication Title**	**Status** *(published, in press, accepted or returned for revision)*	**Nature and % of student contribution**	**Co-author name(s) Nature and % of Co-author's contribution***	**Co-author(s), Monash student Y/N***
2	Does Trade Matter For Growth When The Geographical Instruments Are Randomly Generated?	Under Review	Data collection, computation, partial development, 40%	(1) Jakob B. Madsen, Development and writing up, 30% (2) Laura Puzzello, Idea, development, analysis and writing up, 30%	N N

I have / ~~have not~~ renumbered sections of submitted or published papers in order to generate a consistent presentation within the thesis.

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The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student's and co-authors' contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors.

[redacted]

Main Supervisor signature: [redacted] **Date:** 21.3.'18

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"Every little piece of your life will add up to one,

Every little piece of your life will mean something to someone."

∼ The Editors, The Weight of the World ∼

Chapter 1

Introduction

There is an extensive literature concerning the relationship between trade or trade openness' effect and income. This introduction to the thesis provides a brief discussion of the literature identifying the way trade affects productivity and hence economic growth and income in an endogenous growth model. This is followed by a discussion of the challenges of quantifying this effect using growth regressions. As shown this literature often uses instrumental variable analysis to identify the exogenous variation of trade, our variable of interest. One that is often used is the strategy based on identifying the exogenous variation of trade through the use of geography as first proposed by Frankel and Romer (1999), hence FR. In subsequent chapters the thesis aims to provide the practitioner with more insight into the use of the instrument and which pitfalls to avoid. Section 1.1 provides an overview of the thesis.

Models explaining endogenous growth as a result of trade In endogenous growth models trade's effects on growth and income arise as a result of trade affecting a country's total factor productivity(TFP). The literature identifies several channels through which this occurs.

One such channel is the market integration channel. Technological change is driven by individual's investment decisions in R&D which in turn is driven by the returns on investment, which encompass the development of new goods that can be brought to market. Increased trade through market integration increases the return on investment and therefore an increase in the investment in R&D and thus the growth rate of the economy (Romer, 1990). Alternatively, an increase in trade means an increase in the flow of ideas across borders, increasing returns to scale of R&D (Rivera-Batiz and Romer, 1991).

Coe and Helpman (1995) identify the transmission of knowledge across borders as contributing to a country's productivity level. Globalization and trade play a role in the transmission of knowledge across borders resulting in an improvement of production techniques, more efficient allocation of resources and therefore an increase in an economy's productivity and growth rate. So, it is not just domestic R&D stock and human capital that plays a role here; foreign R&D stock also increases the domestic productivity level. The effect of the foreign R&D stock on productivity, and hence growth, is larger when the domestic R&D stock is larger and the more open a country is to imports. The conclusions hold even when controlling for the level of human capital (Coe et al., 2009) while Engelbrecht (1997) finds that the role of human capital in incorporating the knowledge to increase productivity distinct from the level of R&D stock and its contribution to production as a factor of production. The role of trade in spreading the benefits of new technology is greater the closer a country is to the country that is the source of the new technology. Madsen (2007) finds that 97% of TFP increase in OECD countries over the period 1870 to 2004 can be attributed to trade's contribution to TFP through the import of knowledge.

The beneficial effects on productivity of the indirect transfer of knowledge through the trade of final goods is also applicable to the trade in intermediate inputs, the third channel. Amiti and Konings (2007) show that the lowering of tariffs on intermediate capital goods, and increased trade volumes, increases the productivity of the liberalizing country. The effect on TFP of the trade in intermediate inputs is more relevant for those industries that use intermediates that contain more R&D knowledge (Nishioka and Ripoll, 2012).

Melitz (2003) describes a different channel through which trade affects domestic TFP. In a world of monopolistic competition where firms are heterogeneous in their productivity level and there are non zero cost to selling on foreign markets, only the most productive firms can overcome the costs of selling their products in foreign markets. This also applies to foreign firms selling goods on the domestic markets thereby increasing competition in the domestic market. As a result, the least productive domestic firms are unable to compete and thus exit the market. With the exit of less productive firm overall productivity increases as resources are allocated across remaining domestic firms with on average higher productivity.

A final gain from trade is that the increased competition on the domestic market reduces market power of domestic producers and hence reduces mark-ups and prices. Feenstra and Kee (2008) find that an increase in export product variety increases country productivity. In terms of general welfare, along with the increase product variety consumers will also benefit from the decrease in the prices as a result of trade. Broda and Weinstein (2006) find evidence that for the years 1970-2001 the increase of product variety in the US has been an important contributor to the gains from trade the US experienced at this time.

Using growth and income regressions to quantify the effects of trade Quantifying trade's effect has been the challenge. The literature finds evidence for a positive relationship between trade openness using cross-country regression analysis (Dollar and Kraay, 2004; Sachs et al., 1995; Frankel and Romer, 1999; Noguer and Siscart, 2005; Feyrer, 2009b,a; Pascali, 2017, among others)[1]. At the same time there is evidence that the effects are conditional, i.e. that the effects are different for different countries. For instance, the benefits from trade are dependent on the level of development (DeJong and Ripoll, 2006), or on the business environment (Freund and Bolaky, 2008), or greater when import restrictions are lowered for intermediate rather than final goods (Estevadeordal and Taylor, 2013).

These examples illustrate some of the challenges of answering the question on trade's effect on income. The biggest, however, is due to the fact that trade or trade openness is endogenous to income. One feature of the relationship between trade and income is the simultaneity or reverse causality. Trade leads to higher incomes while at the same time richer, more developed countries trade more. One solution is to use a proxy or instrumental variable for trade that is not determined by income.[2] The other feature is that several determinants of income, for example macroeconomic policy, can affect both trade and income. For example, the quality of government institutions determines the ease of firm entry and quality of infrastructure which in turn affects the level of income as well as the level of trade (Hall and Jones, 1999; Djankov et al., 2002). As a consequence, one needs to control for these factors, which is difficult as many are unobservable.

[1]Another strand of the literature uses detailed multi-country studies or surveys of periods in which the countries that are the subject of the study are liberalizing trade.

[2]A more novel approach is to use natural experiments as identification of the exogenous variation of trade. Feyrer (2009a) exploits the closure of the Suez canal to isolate the effect on the volume of trade of bilateral distance. Subsequently, Feyrer employs IV strategy to estimate trade's effect on income. Although a natural experiment is used to identify the variation of trade exogenous to income, it is essentially still an instrumental variables approach to quantifying trade's effect on income.

One example if the use of tariff or tariff structures as a proxy of trade openness as in Dollar and Kraay (2004); DeJong and Ripoll (2006) and others. The drawback to their use is that this measure does not take into account any non-tariff barriers to trade when considering a country's openness to trade. For this reason others, like Sachs et al. (1995) and in updated form Wacziarg and Welch (2008), construct an index of openness indicating whether a country has liberalized trade or not. In their construction Sachs et al. look beyond the tariff structure imposed by each country but also to assess the degree to which countries impose non-tariff measures on trade and other characteristics of the economy that may hinder trade. One drawback to the use of indexes as proxies for trade or trade openness is that they are often binary - an economy is either open or closed. Rodriguez and Rodrik (2001) identify another drawback to the use of these types of indexes. They show that when using the Sachs et al. (1995) index the results of trade's effect on income are driven by two characteristics used in the construction of the index. This is problematic because each of these characteristics is not just a direct consequence of type of trade policy employed, open or closed, but also a consequence of general macroeconomic policy.

Another option, and the focus of this thesis, is a generated instrumental variable approach. In their seminal paper FR use a simple three-equation model in which international trade is determined by proximity of residents to non-residents. Defining trade in this way sets them up to specify a bilateral equation based on the gravity model of trade using geographic variables. The estimates of the bilateral equation is used to predict bilateral trade and sum across all partners to generate predicted trade. FR make the assumption that the variables they use in their bilateral equation are unaffected by income while strong determinants of trade. If this were not the case the generated instrument would violate the exclusion restriction.[3]

It has not been without its critics. Rodriguez and Rodrik (2001) fault the Frankel and Romer (1999) instrumentation strategy because it assumes that geography only affects income through trade. The literature though has identified other channels than international trade through which geography affects income (Easterly and Levine, 2003; Acemoglu et al., 2001; Rodrik et al., 2004; Putterman and Weil, 2010; Madsen, 2016). Authors find that controlling for these channels leads to insignificant estimates of trade's effect on income. This result has since been revised by Noguer and Siscart (2005) using an improved bilateral trade data set, multiple

[3]The challenge is finding geographic characteristics that are not affected by income while at the same time are highly correlated with trade.

sets of controls and an alternative way of constructing the instrument (see chapters 2 and 3 for a discussion of the approach). Another drawback is the time invariance of geography which limits the application of the FR instrument in a panel setting to exploit country heterogeneity. However, recent adaptations of the strategy have allowed Feyrer (2009b) and Pascali (2017) to find positive effects of trade on income and economic development, respectively.

The instrumentation strategy has also been applied to investigate migration's effect on income (Andersen and Dalgaard, 2011; Ortega and Peri, 2014) and the relative importance of trade and migration in determining income. While working with the FR instrument to analyze globalization's impact on income, questions came up that I could not find answers to in the literature. This thesis is the result of the insights that my research brought me and my contribution to the literature.

1.1 Contribution and Structure of the Thesis

The thesis comprises of three self-contained papers that provide further insight into the FR instrumentation strategy and the underlying mechanism for identification. Although it has been over fifteen years since its publication in 1999, the instrument and adaptations of it are still used in the literature, even in a panel setting as shown by Pascali (2017)'s investigation on globalization's effect on development. The thesis can be viewed as a practitioner's guide to the use of the FR-instrumentation strategy.

Chapter 2 is an investigation into how relevant the bilateral trade specification, used to generate the instrument for trade, is to the outcome of the income equation of the effect of trade openness on income. The question is relevant to the validity of the FR instrument. On the one hand its validity is questionable if a singular covariate (of the thirteen[4]) drives the result that trade has a positive effect on income. Bazzi and Clemens (2013) argue that much of the literature on the determinants of economic growth relies on the use of a single variable, often population, as an instrument for many different determinants of income. They argue that multiple uses of the same instrument invalidates the use of the instrument in all applications as one cannot argue that the use in one setting is superior to the same instrument's use in another setting. If a singular covariate ends up driving the result, this critique applies to the

[4]The bilateral trade equation used by FR contains seven covariates and six interaction terms.

FR instrumentation strategy possibly invalidating its use.

Alternatively, the FR instrument is invalid if significant results can be achieved using instruments generated with a specification that does not reflect the gravity model of trade. Fundamentally, an instrument's validity relies on the theoretical foundation for its use (Murray, 2006). The FR instrument's validity is based on generating predicted trade using the gravity model of trade. Therefore, the validity of the FR instrument is questionable if similar significant results are generated using instruments generated by specifications with singular or few covariates that do not adequately reflect the gravity model of trade.

First, I generate different instruments using each and every unique specification containing at least one of the covariates of the original bilateral trade equation. I generate each instrument by predicting bilateral trade only for actual trading partners before summing to construct predicted total trade share for each country in my sample. In this I follow the methodology proposed by Noguer and Siscart (2005) because it reduces the noise captured by the instrument when it is predicted across all partners and the results of trade's effect on income are more robust. In the next step each individual generated instrument is then used as an instrument for trade in the income regression and each estimate for trade openness is compiled into a data set. The results in the data set form the evidence for drawing conclusions on the sensitivity of the FR result to changes in the specification used to construct the instrument.

One finding is that an instrument generated using a singular covariate produces robust results. Trade's effect continues to be positive, significant and credible, i.e. the estimates are similar to those found in the literature and the instrument itself is strong. However, a singular covariate does not adequately reflect a translation of the gravity model of trade to an equation with geographic determinants. This raises concerns about what variation the instrument is identifying.

This finding is the starting point of the analysis in chapter 3. My co-authors and I reason that there must be another source driving the results. To discover this driver of the robustness of the instrument, we conduct a Monte Carlo style analysis whereby two instruments for trade are generated for each set of repeatedly created random geographic data. One instrument is the sum of predicted bilateral trade across actual partners as used in the previous chapter. The second instrument is the sum of predicted trade for all possible partners as originally proposed by FR. By using random data, the generated instruments should not contain any information to identify cross country variation of actual trade openness. A contrary result is evidence that there is an alternative driver and allows us to identify the cause. The chapter contributes to the existing literature by showing clearly the consequences of an innocent methodological choice in generating the instrument on instrument validity.

Chapter 4 aims to broaden our knowledge of the geographic controls required to validate the use of the FR instrument as well as improve our understanding of trade and migration's effects on income once Foreign Direct Investment(FDI) is taken into consideration. As Rodriguez and Rodrik (2001) point out, failing to control for other geography's effect on income through other channels means that the exclusion restriction is violated and the estimate for trade is biased. Since the paper's publication, controlling for an array of geographic channels has become standard practice in the literature when the FR instrument is used. Ortega and Peri (2014) argue that one additionally needs to include migration in the income regression of trade on income when using the FR. There is evidence that migration affect income. And like trade, bilateral migration is also determined by geography and the gravity model is a good predictor of the size of migration flows.

I argue, in chapter 4, that one must therefore also control for FDI when using the FR instrument for trade. Like controlling for migration and other geographic channels, controlling for FDI is expected to improve the estimate for trade's effect on income as the instrument for trade captures more than just the exogenous variation of bilateral trade as a result of relative geography (Feyrer, 2009b).

Consequently, chapter 4 extends the Ortega and Peri (2014) analysis first, by including FDI alongside migration as an additional control, and secondly, by using a panel data set as opposed to the cross-sectional approach used by Ortega and Peri. I use the FR instrumentation strategy to generate the instrument for all three endogenous regressors in the income equation, trade openness, migration openness and FDI openness.

Chapter 5 summarizes the findings of the Chapters 2 through 4 and discusses some considerations for future research and applications of the instrument. The takeaways for the practitioner from these chapters are threefold. First, Chapter 2 provides evidence that FR-instrument is robust to the exclusion of individual covariates so does not risk being invalidated when individual covariates are used as instruments for endogenous determinants of income, other than trade. Secondly, when generating predicted trade share one must always generate the instrument by summing predicted trade for all possible partners in the sample. Excluding partners with zero or no trade in the summation will cause the generated instrument to be endogenous to income because is captures the number of partners. The final takeaway is that one cannot use the FR-instrument for more than one endogenous regressor to identify individual effects. The reason is that each instrument makes use of the same variation of the covariates in the bilateral equation, and therefore does not allow the practitioner to interpret the estimates in the traditional sense.

References

Acemoglu, D., Johnson, S. and Robinson, J. A. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation, *The American Economic Review* **91**(5): 1369–1401.

Amiti, M. and Konings, J. (2007). Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia, *American Economic Review* **97**(5): 1611–1638.

Andersen, T. B. and Dalgaard, C.-J. (2011). Flows of people, flows of ideas, and the inequality of nations, *Journal of Economic Growth* **16**(1): 1–32.

Bazzi, S. and Clemens, M. A. (2013). Blunt Instruments: Avoiding Common Pitfalls in Identifying the Causes of Economic Growth, *American Economic Journal: Macroeconomics* **5**(2): 152–186.

Broda, C. and Weinstein, D. E. (2006). Globalization and the Gains from Variety, *Quarterly Journal of Economics* **121**(2): 541–585.

Coe, D. T. and Helpman, E. (1995). International R&D spillovers, *European Economic Review* **39**(5): 859–887.

Coe, D. T., Helpman, E. and Hoffmaister, A. W. (2009). International R&D spillovers and institutions, *European Economic Review* **53**(7): 723–741.

DeJong, D. N. and Ripoll, M. (2006). Tariffs and Growth: An Empirical Exploration of Contingent Relationships, *The Review of Economics and Statistics* **88**(4): 625–640.

Djankov, S., La Porta, R., Lopez-De-Silanes, F. and Shleifer, A. (2002). The Regulation of Entry, *Quarterly Journal of Economics* **117**(1): 1–37.

Dollar, D. and Kraay, A. (2004). Trade, Growth, and Poverty, *Economic Journal* **114**(493): F22–49.

Easterly, W. and Levine, R. (2003). Tropics, germs, and crops: how endowments influence economic development, *Journal of Monetary Economics* **50**(1): 3–39.

Engelbrecht, H.-J. (1997). International R&D spillovers, human capital and productivity in OECD economies: An empirical investigation, *European Economic Review* **41**(8): 1479–1488.

Estevadeordal, A. and Taylor, A. M. (2013). Is the Washington Consensus Dead? Growth, Openness, and the Great Liberalization, 1970s-2000s, *Review of Economics and Statistics* **95**(5): 1669–1690.

Feenstra, R. and Kee, H. L. (2008). Export variety and country productivity: Estimating the monopolistic competition model with endogenous productivity, *Journal of International Economics* **74**(2): 500–518.

Feyrer, J. (2009a). Distance, Trade, and Income - The 1967 to 1975 Closing of the Suez Canal as a Natural Experiment, *Working Paper 15557*, National Bureau of Economic Research.

Feyrer, J. (2009b). Trade and Income – Exploiting Time Series in Geography, *Working Paper 14910*, National Bureau of Economic Research.

Frankel, J. A. and Romer, D. (1999). Does Trade Cause Growth?, *American Economic Review* **89**(3): 379–399.

Freund, C. and Bolaky, B. (2008). Trade, regulations, and income, *Journal of Development Economics* **87**(2): 309–321.

Hall, R. E. and Jones, C. I. (1999). Why Do Some Countries Produce So Much More Output Per Worker Than Others?, *The Quarterly Journal of Economics* **114**(1): 83–116.

Madsen, J. B. (2007). Technology spillover through trade and TFP convergence: 135 years of evidence for the OECD countries, *Journal of International Economics* **72**(2): 464–480.

Madsen, J. B. (2016). Barriers to Prosperity: Parasitic and Infectious Diseases, IQ, and Economic Development, *World Development* **78**: 172–187.

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity, *Econometrica* **71**(6): 1695–1725.

Murray, M. P. (2006). Avoiding Invalid Instruments and Coping with Weak Instruments, *Journal of Economic Perspectives* **20**(4): 111–132.

Nishioka, S. and Ripoll, M. (2012). Productivity, trade and the R&D content of intermediate inputs, *European Economic Review* **56**(8): 1573–1592.

Noguer, M. and Siscart, M. (2005). Trade raises income: a precise and robust result, *Journal of International Economics* **65**(2): 447–460.

Ortega, F. and Peri, G. (2014). Openness and income: The roles of trade and migration, *Journal of International Economics* **92**(2): 231–251.

Pascali, L. (2017). The Wind of Change: Maritime Technology, Trade, and Economic Development, *American Economic Review* **107**(9): 2821–2854.

Putterman, L. and Weil, D. N. (2010). Post-1500 Population Flows and the Long-Run Determinants of Economic Growth and Inequality, *Quarterly Journal of Economics* **125**(4): 1627–1682.

Rivera-Batiz, L. A. and Romer, P. M. (1991). Economic integration and endogenous growth, *Quarterly Journal of Economics* **106**(2): 531.

Rodriguez, F. and Rodrik, D. (2001). Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence, *NBER Macroeconomics Annual 2000*, Vol. 15, MIT PRess, pp. 261–338.

Rodrik, D., Subramanian, A. and Trebbi, F. (2004). Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development, *Journal of Economic Growth* **9**(2): 131–165.

Romer, P. M. (1990). Endogenous Technological Change, *Journal of Political Economy* **98**(5): S71–S102.

Sachs, J. D., Warner, A., Åslund, A. and Fischer, S. (1995). Economic Reform and the Process of Global Integration, *Brookings Papers on Economic Activity* **1995**(1): 1–118.

Wacziarg, R. and Welch, K. H. (2008). Trade Liberalization and Growth: New Evidence, *The World Bank Economic Review* **22**(2): 187–231.

Chapter 2

Geography as an instrument for trade: how many explanatory variables does it take?

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Abstract
The instrumental variable introduced by Frankel and Romer (1999) in their seminal paper uses geographic characteristics and the gravity model of trade to generate an instrument for trade openness. This paper addresses the question: how much does the specification of the bilateral trade equation used to generate the instrument for trade, matter for the outcome that trade affects income? The importance of this question is highlighted by Bazzi and Clemens (2013) who argue that the instrument may possible be invalidated if any of the covariate used to generate the instrument is driving the result and that same covariate is used as instrument in another setting. Another concern is that the many covariates lead to an overfitting bias because the generated instrument may capture more than the variation of trade that is exogenous to income. In order to answer this question instruments are generated using different specifications from the original set of explanatory variables. The paper finds that the results of Frankel and Romer (1999) are robust to the different specifications used to generate the instrument. This is reassuring as trade's positive effect on income is not dependent on a specific covariate. On the other hand, the results pose a puzzle requiring further investigation as generating the instrument from a singular covariate leads to significant, positive results in six out of seven instances.

JEL: F14, F43, O40
Key words: Trade-growth nexus, Geography

2.1 Introduction

A major challenge in the empirical literature has been quantifying the effect that a country's trade openness has on income.

Countries gain from trade because of trade's effect on a country's total factor productivity (TFP) and hence growth and income. The literature identifies several channels. Market integration through trade creates incentives to invest more in R&D because the return to investment has increased with the increase in the size of the market for the final goods produced using the R&D knowledge (Rivera-Batiz and Romer, 1991). Trade also facilitates knowledge and R&D spillovers which if assimilated can lead to an increase in TFP (Coe and Helpman, 1995). Distinct from knowledge spillovers, is the channel of trade in intermediate goods or capital goods that improve TFP and hence income (Amiti and Konings, 2007). Trade also impacts a country's TFP through the exit of less competitive firms as a result of increased competition from goods produced by more productive foreign firms[1]. The exit of less productive firms and reallocation of resources toward more productive domestic firms that have increased their output as a result of access to foreign markets through trade leads to an increase in TFP (Melitz, 2003). And finally, trade affects income through the product variety channel. As the number of goods in the market increases, firms will have to make do with lower mark-ups which reduces costs of final as well as intermediate goods leading to TFP gains (Feenstra et al., 1999; Feenstra and Kee, 2008).

One of the complications in quantifying the size of the effect of trade on income is the presence reverse causality between trade and income. While the more a nation trades the higher it's income, the reverse is also true; the higher a country's income the more it will trade. Another complication is the presence of omitted variable bias if in the equation of interest one does not control for factors that affect both income and trade, for example a country's transport infrastructure or macro-economic policy. The challenge is to find adequate measures or proxies for these other factors because they are often unobservables or difficult to measure across countries.

In their seminal paper Frankel and Romer (1999), henceforth FR, pioneer the use of a gen-

[1] Given non zero costs of exports only the most productive firms within an economy will be competitive in foreign markets and able to afford to export their goods abroad.

erated instrument based on a country's relative geography, specifically proximity. FR propose estimating a bilateral trade equation that is based on the gravity model of trade and specified using geographic characteristics for covariates. Using the estimates, bilateral trade is predicted and then summed over all partners to construct a measure of each country's predicted trade. This is the instrumental variable in the specification of interest, of income on trade.

The generated instrumental variable solves the endogeneity issue because geography affects income through trade while income does not affect a country's geographic characteristics, such as distance to trading partners, area, and landlockedness, thereby eliminating the reverse causality. [2]

The intuitive appeal of the specification of the bilateral trade equation and the empirical success of the gravity model of trade (Anderson, 2011) has led to the widespread use of the instrument (5500 citations and counting[3]). Most studies have confirmed the original result of trade's positive effect on income (Irwin and Terviö, 2002; Noguer and Siscart, 2005; Feyrer, 2009a,b; Ortega and Peri, 2014).

Through the years authors have used different specifications of the bilateral trade equation to generate an instrument for trade, often including but also excluding covariates. However, there has not been a single paper that has researched how changing the specification of the bilateral trade equation used to generate the instrument affects the results of interest.

This paper fills that gap. The aim of the paper is to investigate to what extent the positive effect of trade openness on income found by FR and others is robust to the specification of the bilateral trade equation used to generate the instrument.

If the results are mostly positive and significant irrespective of the specification of the bilateral trade equation used, one can question the generated instrument's validity as an instrument for trade. This can be the case for a specification that does not relate to the gravity model of trade on which the instrumentation strategy is founded. Another concern is that the instrument is invalid if the result and strength of the instrument is caused by a single covariate. If that covariate is also used as a valid instrument in a different setting the FR-instrument could possibly be invalid. (Bazzi and Clemens, 2013). On the other hand, using an extended set of

[2]The challenge is to find geographic determinants of trade that are strongly correlated with trade while at the same time not affected by income and not correlated with income.

[3]Number of citations given by Google Scholar on 31$^{\text{st}}$ of October 2017.

covariates in the bilateral trade equation runs the risk of overfitting the endogenous regressor in the equation of interest and biasing its coefficient.

The starting point for the methodology employed in this paper is the original specification of the bilateral trade equation as proposed by FR. The specification consists of 7 geographic variables. I consider specifications of all possible combinations with 1, 2, 3, 4, 5, 6 or 7 covariates. If the border term is included in the specification with at least one other covariate, I construct additional specifications that include one or more interaction terms of border with the other covariates. This results in 792 specifications of the bilateral trade equation (including the original FR-specification) and generated instruments. I then use each of these instruments individually in the analysis of income on trade. The results are analyzed with particular focus on the size and significance of the estimated coefficients for trade share as well as the first-stage F-statistics as indicators of instrument strength. Also of interest is the frequency of positive and significant estimated coefficients and how often significant results are produced using a strong instrument.

The paper finds that a large proportion of these different instruments produce significant positive estimates for trade share in the income regression while also being strong instruments. Dropping singular covariates, does not greatly affect the results means that the FR-instrument is not invalidated by the use of any covariate in another setting. The results are robust to the inclusion of different additional channels through which geography affects income. The results are also robust to extending the set of covariates in the bilateral trade equation to include covariates used in the more recent literature.

There is one issue that is cause for concern. The results show that a single covariate in the bilateral trade equation is able to generate strong instruments that produce positive, significant estimated coefficients for trade's effect on income. The covariate that on its own generates a weak instrument and insignificant estimate of trade's effect on income, is bilateral distance. Given that bilateral distance is a very direct measure of proximity and main determinant in the gravity model, it is puzzling outcome and a possible avenue for further research.

The paper is set up as follows. After reviewing the relevant literature, the subsequent section details the original Frankel and Romer-methodology and the methodology used in this paper. This is followed by a data section which includes a replication of the result found in Frankel and Romer (1999) to demonstrate that the results in this paper are not caused by the data used. Section 2.5 will present the results including the robustness before section 2.6 concludes.

2.2 Literature Review

As Murray (2006) notes, the validity of any instrument must be motivated well. The best instruments are those that besides being intuitively plausible and empirically valid have a theoretical foundation.

The use of a specification based on the gravity model of trade to predict trade that is exogenous to income through the use of geographic determinants is intuitively appealing. As Anderson (2011) notes the gravity model as an empirical model is very successful. Any instrument based on the gravity model is expected to be highly correlated with the endogenous regressor, trade and therefore a strong instrument.

Theoretical foundations The gravity model has a solid theoretical foundation in the literature. Traditionally the gravity model of trade relates the volume of bilateral trade to the countries' income, bilateral distance and additional characteristics that affect the barriers to bilateral trade. The specifications have often centered explaining the determinants of bilateral trade using determinants that are country specific or relate to the country-pair, like bilateral distance. And like bilateral distance these determinants are easily identified by measurable geographic country characteristics. In this FR hope to capture the resistance to bilateral trade that is exogenous to income so one can identify the volume of trade that is exogenous to income.

However, the specification as defined by FR may suffer from omitted variable bias. As Anderson and van Wincoop (2003) point out using only country specific or country-pair specific determinants does not take into account that the resistance to trade is not purely determined by the bilateral trade barrier but by the bilateral barrier relative to each country's average trade barrier with all trading partners. Anderson and van Wincoop call this the 'multilateral resistance' term, which can cover all factors that pose barriers to trade. Identification of the multilateral resistance term in all its facets is challenging. Anderson and van Wincoop note that the often used remoteness index, which tries to capture a countries relative distance to all its trading partners, comes close but often only covers one specific factor that inhibits trade.

In their study confirming the FR, Noguer and Siscart (2005) mention (but do not report) that inclusion of multilateral price indexes for both partner and reporter country in the bilateral trade equation used to generate instruments do not qualitatively affect the results. I find the inclusion of these covariates questionable as one could be introducing determinants that are endogenous to income. I concur with their assessment that excluding the multilateral price indexes would not automatically invalidate the instrument for trade. as it is "plausibly exogenous and highly correlated to trade"(Noguer and Siscart, 2005, p.456), which is the basic requirement for instrumental variables.

Variations of the specification used to generate the instrument The theory does not prescribe which and how many covariates of geography are needed in a specification to generate an instrumental variable for trade based on the gravity model. The original specification used by FR is:

$$\begin{aligned}\ln(tsh_{ij}) =& \beta_0 + \beta_1 \ln(D_{ij}) + \beta_2 \ln(N_i) + \beta_3 \ln(A_i) + \beta_4 \ln(N_j) \\ &+ \beta_5 \ln(A_j) + \beta_6(L_i + L_j) + \beta_7 B_{ij} + \beta_8 B_{ij} \ln(D_{ij}) \\ &+ \beta_9 B_{ij} \ln(N_j) + \beta_{10} B_{ij} \ln(A_i) + \beta_{11} B_{ij} \ln(N_i) \\ &+ \beta_{12} B_{ij} \ln(A_j) + \beta_{13} B_{ij}(L_i + L_j) + \epsilon_{ij}\end{aligned} \tag{2.1}$$

where tsh_{ij} is the total bilateral trade between country i and country j divided by country i's GDP; D_{ij} is the geographic distance between country i and j; L is a dummy variable that takes on the value of 1 for landlocked countries and zero otherwise; B_{ij} is an indicator variable taking the value of 1 if countries i and j share a border and zero otherwise; and ϵ is a stochastic error term.

Throughout the literature using the FR-instrument, different specifications have been used to generate the instrument. Each variation does little to influence the outcome in the equation of interest, trade's effect on income.

As a test of robustness of their instrumentation strategy in their original publication FR drop certain covariates in the bilateral trade equation, which they believed could be thought of as endogenous to income in the long run. FR run four variations: first they omit the landlocked dummies, then, they exclude population of both the reporter as well as the partner country.

Thirdly they exclude the border interaction terms with each and every other geographic covariate in the specification and lastly they exclude area of partner and reporter country. A fifth variation to test the robustness of the initial results, alters the measure of population used.[4] Using the corresponding instruments did not affect their results. The effect of trade on income was still relevant and significant.

Subsequent authors have chosen to drop covariates from, or add covariates to, the original specification proposed by FR. Investigating trade's effect on income in different cross sections throughout the 20$^{\text{th}}$ century, Irwin and Terviö (2002) construct their instrumental variable for trade without the border interaction terms. Their findings are comparable to that of FR for most cross-sections; trade is relevant and significant determinant of income.

More recent adaptations of the bilateral trade equation to construct an exogenous trade share based on geography, also find strong evidence for the positive relationship between trade and income using valid instruments. Feyrer (2009b) instrument trade in a panel setting using two measures of bilateral distance as well as country and time fixed effects to capture other determinants of bilateral trade. In this way bilateral trade becomes a function of sea distance, the number of days for a round trip between the primary ports of two countries, and air distance, proxied by the population weighted great circle distance between the two major cities. Despite this seemingly simple specification of the bilateral trade equation, Feyrer not only finds evidence in support of FR but also and more importantly for the analysis here that the instrumental variable is a strong and valid instrument.

The danger that dropping covariates pose is that the specification used to generate ceases to resemble the gravity model of trade. Another danger is that the instrument generated relies on one or two covariates that may also be valid instruments in other settings. The more reliant the result is on a single covariate the more extensive the required motivation needs to be to establish instrument validity (Bazzi and Clemens, 2013). If the covariate driving the result is also used as an instrumental variable for a different endogenous determinant of income, then the exclusion restriction will not be met if you do not control for this alternative channel. However, simply controlling for the additional regressor is insufficient. One needs to find an instrumental variable that remains strong when used with your instrumental variable.

[4] In their baseline analysis FR use labor force instead of total population in their original study. This distinction is not seen in later literature and will not be made in this paper.

Others expand on the original FR specification for the bilateral trade equation including additional factors such as a shared colonial past, common language (Ortega and Peri, 2014) or war (Glick and Taylor, 2010).

Although in each case the use of these 'additional' covariates is well supported by the literature as they have been found to have been determinants of trade, there are two concerns. The first is that these factors may not be exogenous to income and any instrument of trade constructed using this specification therefore does not meet the exclusion restriction . This is especially pertinent to the use of fixed effects in the estimation of the bilateral trade equation and prediction of the instrumental variable. For example country fixed effects capture country-specific trade policy which is likely to be endogenous and not exogenous to income. For this reason Ortega and Peri (2014) estimate the gravity equation using fixed effects but exclude them when predicting bilateral trade in order not to contaminate the instrumental variable. Feyrer (2009b)'s solution is that the use of country fixed effects in the structural analysis will control for any endogeneity captured by the instrument. A second concern is that inclusion of additional variables is the main reason that the instrumental variable used in the structural analysis is a strong instrument. The instrument may be overfitting the endogenous variable leading to biased estimates of the variable of interest. (Roodman, 2009)

2.3 Methodology

The causal relationship of interest is that of trade's effect on a country's income.

FR define a country's income, Y_i, as a total of economic interactions conducted by residents. Residents interact with other residents and the sum of those interactions is called within-country trade, W_i. Residents also interact with foreigners and the sum of residents' interaction with foreigners is called international trade, T_i. Formally:

$$\ln(Y_i) = \gamma_0 + \gamma_1 T_i + \gamma_2 W_i + \epsilon_i \tag{2.2}$$

where ϵ_i is the residual capturing all other influences on income. γ is the estimate of interest in a study of international trade's effect on income.

Equation (2.2) can not be estimated in its current form because there is not a satisfactory measure for within-country trade, W_i. By defining within country trade as the sum of transactions between residents of country i, the larger the country is the more residents interact with other residents, so within-country trade is a function of country size. FR use geographic area, A_i, and population, N_i, as proxies for country size. An advantage of using these proxies is that they are not endogenous to income.

Using these proxies for within country trade, as well as income per capita as a measure for income and trade share as measures for trade, allows for equation (2.2), the relationship of interest, to be rewritten as:

$$\ln(y_i) = \alpha_0 + \alpha_1 TSH_i + \alpha_2 \ln(N_i) + \alpha_3 \ln(A_i) + u_i \tag{2.3}$$

where y_i is country i's real GDP per capita and TSH_i is the country's trade share measured as the total trade (exports plus imports) over the country's nominal GDP. Although imperfect, the sum of interactions with foreigners can be measured by a country's trade openness or the share of trade relative to income, TSH_i.

It may seem odd to include population as a regressor on the RSH of the equation when using income per capita as the dependent variable. However, because country size and country openness are negatively correlated excluding population will lead to α_1, the coefficient for trade share to be biased. Including population in the income equation avoids the bias of α_1 as a result of population induced effects on trade share and on income per capita. There is a second related issue that needs to be highlighted here. Besides population, income also enters both the LHS (as the numerator in y) and the RSH (in the denominator of TSH_i). For any increase in income that is not trade induced, a country's trade share will decrease. As a result an OLS estimate of α_1 will be negatively biased; in the extreme case it can take on the value of -1. Using an instrumental variable for TSH_i, overcomes this bias.

Like trade, though, the measure of trade openness, TSH_i, is endogenous to income. FR propose using predicted trade openness as an instrument. The specification used to generate the instrument is based on the gravity model of trade and uses a set of geographic covariates to capture the proximity of residents to foreigners.

First, the following bilateral trade equation is estimated:

$$\ln(tsh_{ji}) = \mathbf{b}'\mathbf{G_{ij}} + v_{ij} \tag{2.4}$$

where tsh_{ji}, the bilateral trade share, is the quotient of bilateral trade (exports from i to j plus the bilateral imports from j to i) and country i's nominal GDP and $\mathbf{G_{ij}}$ a set of observable geographic determinants of bilateral trade.

Following FR, the complete set $\mathbf{G_{ij}}$ contains thirteen covariates. The first seven are bilateral distance (D_{ij}), each country's population[5] (N_i, N_j) and area (A_i, A_j), a dummy variable equal to one if the country pair have a shared border (B_{ij}) as well as the sum of landlocked dummies (L_i+L_j) equal to one if one country in the pair is landlocked and two if both are landlocked countries. The remainder are interaction terms of the border dummy with each of the other six covariates in the set.

For each country pair in the data set, the bilateral trade share is predicted using the estimates $\widehat{\mathbf{b}}$. The final step is taking the exponent of the predicted value and summing over all partner countries, j, for each country i. The result is a total trade share for each country i [6]:

$$\widehat{TSH}_i = \sum_{j \neq i} e^{\ln \widehat{tsh}_{ij}} = \sum_{j \neq i} e^{\widehat{\mathbf{b}'}\mathbf{G_{ij}}} \tag{2.5}$$

This total predicted trade share, $\widehat{TSH}_i$, is the exogenous variation in country i's trade share that is determined by its geography and is the instrument for actual trade share, TSH_i in equation (2.3).

Constructing all possible specifications of the bilateral trade equation To test the robustness of the FR instrument to the specification of the bilateral trade equation, I generate

[5]One can argue that population is not exogenous to income. FR acknowledge that in the long run population may be endogenous to income. Therefore in their robustness test they exclude population from the bilateral trade equation used to generate the instrument. The subsequent results corroborate their main findings. In addition, my results also show that the omission of individual covariates has little effect on the size and significance of the estimates for trade openness as well as instrument strength. Furthermore, population may be affected by migration and FDI for which one needs to control in the income equation. As both are indeed affected by country income, both need to be instrumented to avoid biased estimates of their effect on income in any income equation. See Ortega and Peri (2014). The current paper does not address these issues.

[6]To simplify the summation FR assume that v_i is homoskedastic even though the data itself are likely heteroskedastic. The assumption allows for the exponent of the summed error terms to being (dropped as the exponent of the error terms are a constant multiple (FR, footnote 10 on page 384).

instruments using unique combinations of elements from the covariate set $\mathbf{G_{ij}}$. I exclude interaction terms if their constituent covariates are not in the combination of selected covariates. For example, I exclude the interaction term of border with distance if I have not already included distance and border in the specification.

In total, 792 unique subsets can be constructed, including the full set $\mathbf{G_{ij}}$.[7] Each of these subsets will be used to generate 792 instruments including the original FR instrument.

Using each of these 792 generated instruments, the income equation (equation (2.3)) is estimated 792 times. The results for each regression are saved to analyze the persistence of the results to variations in the specification generating the instrument for trade share. The expectation is that the larger the variation, the less likely the results are significant and the less likely the instrument is a strong instrument.

Some particulars All of results reported in the paper take into account the adjusted standard errors, a consequence of using a generated instrument. The reason is that one must allow for the possibility that the estimated coefficients for the bilateral trade equation (from equation (2.4)) used in the construction of the instruments are estimates of the true value and can deviate from the estimated values. The adjusted variance-covariance matrix, $\mathbf{\Sigma}^{adj}$, is constructed as follows:

$$\mathbf{\Sigma}^{adj} = \mathbf{\Sigma} + (\partial \mathbf{a} \backslash \partial \mathbf{b}) \times \mathbf{\Omega} \times (\partial \mathbf{a} \backslash \partial \mathbf{b}) \tag{2.6}$$

where $\mathbf{\Sigma}$ is the variance-covariance matrix from regressing the income equation, $(\partial \mathbf{a} \backslash \partial \mathbf{b})$ is the gradient matrix in which the partial derivative of the estimated coefficients in the income equation, $\mathbf{a}$, with respect to minimal changes in each individual estimated coefficient in the bilateral trade equation, $\mathbf{b}$. $\mathbf{\Omega}$ is the variance covariance matrix of estimating the bilateral trade equation.

Unlike FR, the instrument is generated by only predicting bilateral trade shares for those country pairs actually reporting trade as suggested by Noguer and Siscart (2005), hence NS. I refer to this prediction method as in-sample prediction. By predicting in-sample NS hope to remove noise from the construction of the instrument thereby strengthening the instrument as well as reducing the standard error on the estimated coefficient of trade share in the income

[7]See Appendix 2B for an extensive explanation.

equation. In the next section the baseline results using the full covariate set $\mathbf{G_{ij}}$ will demonstrate this and motivate the use of the in-sample predicted instrument.

A third note on the methodology used here is how the paper addresses the critique by Rodriguez and Rodrik (2001) on the use of the FR instrument. Rodriguez and Rodrik posit that trade is not the only channel through which geography affects income and for that reason one needs to control for other channels. The literature identifies institutions (Rodrik et al., 2004; Hall and Jones, 1999), agricultural productivity (Easterly and Levine, 2003), propensity of diseases and their effect on the human capital productivity (Acemoglu et al., 2001; Madsen, 2016).

Therefore, besides regressing the basic income equation (2.3), I also regress the following specification:

$$\ln(y_i) = \alpha + \alpha_1 TSH_i + \alpha_2 \ln(N_i) + \alpha_3 \ln(A_i) + \alpha_{\mathbf{4}}' \mathbf{X_i} + u_i \tag{2.7}$$

where N_i is population, A_i is the geographic area of country i, and $\mathbf{X_i}$ is a set of controls that are often used in the literature. The paper follows the determinants identified by NS. These are combinations of, in no particular order, distance to the equator, regional dummies, percentage of land in the tropics, percentage of population in the tropics, indices on the quality of governance (ICRG, corruption, PolityIV) and legal origin.

Since the publication of FR the literature has extended the set of covariates used. To incorporate this, the analysis is extended by adding three additional covariates to the set of covariates $\mathbf{G_{ij}}$ in equation (2.4) and generating instruments for every possible specification from this set of 10 covariates. The three additional covariates are a dummy variable equal to one if countries i and j share a common official language, a dummy variable equal to 1 if countries in the pair have or had a colonial relationship, and thirdly, the covariate time difference. The set of covariates does not include the border interaction terms with these additional covariates. As a result of the extension of the set of covariates $\mathbf{G_{ij}}$, a total of 6,343 unique subsets can be constructed.[8] As before, each of these subsets is used to generate 6,343 instruments which are then used as instruments in the basic income equation (2.3).

I now turn to presenting the data sets used and reporting the results of using different

[8]This includes the original 792 subsets that were constructed using the original FR bilateral trade specification. The three covariates themselves lead to 7 unique subsets. To this we add 792 original subsets as well as 7 times 792 subsets so that we have every unique combination of the covariates. In total there are 6,343 subsets.

specifications of the bilateral trade equation to generate the instrument.

2.4 Data

The data sets are constructed for the year 1985 using FR and NS as guides to ensure that the results presented below are not driven by the choice of the data. To ensure comparable data the analysis is executed using an outdated version of the Penn World Tables (PWT) Mark5.6.

It is important to note that the data set is not an exact replica of the data used in the papers referenced above. There are some deviations in order to extend the number of non-missing/non-zero observations of bilateral trade and increase the accuracy of the instrument for trade share. All sources are widely used in the literature to estimate the bilateral trade equation (2.4) and therefore a legitimate alternative to the sources used by FR (Head et al., 2010; Ortega and Peri, 2014). In this section I first outline the construction of the data set used. I then show that my data set replicates FR and NS, confirming that the instrument predicted in-sample provides more robust results justifying the use of the in-sample instrument in my analysis.

2.4.1 Data set construction

I follow FR and NS and use the Mankiw et al. (1992)-sample countries. So, the country data covers 98 countries and the bilateral set includes bilateral observations of each sample country with 161 partner countries.

Country data set Following FR the paper uses the PWT Mark5.6 as the source for Real GDP per capita, population, and trade openness measure. In contrast to FR, this paper sources geographic area from the CEPII *GeoDist* database.

I supplement these variables with additional geographic and institutional variables. Distance to the equator and latitude are sourced from CEPII *GeoDist*[9] and percentage of a country's area located in the tropics.[10] CID Geography Data, supplemented by data from the CIA Factbook,

[9]Distance to the equator is the absolute value of the latitudinal coordinates of each country's main city, divided by 90 while latitude is the true value of the same coordinate divided by 90. The main difference between the two variables is that the second distinguishes the countries located south of the equator from those with identical latitudinal coordinates north of the equator.

[10]The tropics are defined as the area located between the Tropic of Capricorn and the Tropic of Cancer.

provides the data on the the percentage of a country's area or population located in the tropics. The variables to control for quality of institutions or governance are Knack and Keefer (1995)'s ICRG Index and an index of corruption compiled by the IRIS/PRS Group, executive constraint from PolityIV-Project and legal origin from La Porta et al. (2008).[11] Easterly and Levine (1997) index of ethno-linguistic fractionalization, completes the country data set.

Bilateral data set Bilateral trade share, tsh_{ij} is constructed from dividing bilateral trade, the sum of exports from i to j and imports to i from j, by country i's GDP. The source for bilateral trade data is the IFS Direction of Trade Statistics(DOTS) . FR use a data set sourced from DOTS. NS, however, use the data set World Trade Flows as presented by Freenstra(1997) because it provides better coverage. Currently DOTS provides even more observations for the year 1985, which is the reason for using DOTS. GDP data used to calculate the bilateral share is sourced from PWT Mark5.6 identical to FR.

The bilateral data set contains 15,778 (147countries $\times$ 161 partners each) observations of which about 62% are non-zero, non-missing observations for bilateral trade. Compared to FR, this bilateral data set has more non-zero, non-missing observations of bilateral trade share as well as larger country coverage. The expectation is that as a result of having more observations to estimate the bilateral trade equation, the estimated coefficients of the bilateral trade are more accurate increasing their predictive power and thus the strength of the instrument (Noguer and Siscart, 2005; Ortega and Peri, 2014; Irwin and Terviö, 2002). The following replication results demonstrate this.

The bilateral distance measure used is the population-weighted great-circle distance between two main cities from CEPII *GeoDist* database. In contrast to the measure used by FR and NS the weighted measure incorporates the dispersion of a country's population across its territory and therefore more accurately reflects the concept of Proximity as defined by FR as the distance between residents of country i and residents of trading partner, country j.

Population for country i and country j are sourced from PWT Mark5.6, supplemented by population data from the World Development Indicators(WDI) to extend the set of partner countries. An important note is that in the original paper FR use country's labor force as the population measure but conduct robustness test to ascertain that replacing labour force by

[11]This is an updated version of the data set to the one used by NS.

population does not change the results. The literature with regard to bilateral trade does not make this distinction between total population and labour force therefore this paper uses total population as the measure of population in the bilateral trade equation.

Geographic area, the dummy variables for common border and landlocked are also sourced from CEPII *GeoDist*. The latter is summed for each country pair in the sample which means that the covariate can take on values 0, 1 and 2 depending on whether none, one or two countries in the pair are landlocked. The CEPII *Gravity* database constructed by Head et al. (2010) is the source for the analysis using three additional covariates to the seven found in FR: Official Common Language, Colony (indicator of a (former) colonial relationship) and time difference (in hours).

An extensive description of the sample and data set construction can be found in Appendix 2A.

2.4.2 Basic replication

I first generate the instrument by estimating the bilateral trade equation (2.4) using all of the geographic determinants in set $\mathbf{G_{ij}}$.

Table 2.1 shows the results alongside those of FR and NS. As in previous studies, the estimated coefficients have the expected signs. Furthermore the size of the estimated coefficients of each of the covariates is comparable to the estimates by NS with the exception of the estimate for the border covariate. The estimate for border is comparable to the estimate found by FR. As in the previous studies, all estimated coefficients are significantly different from zero at the 5% level with the exception of the interaction terms, which corresponds to the original findings by FR.[12] Finally, the R^2 is similar to that of the original estimation result indicating that the specification explains the same proportion of the variation of the bilateral trade share.

In conclusion, despite having more observations of non-zero bilateral trade, the results are in line with those found in the original study and similar studies. It follows that using these comparable estimates to predict bilateral trade share and construct overall trade share for each country i should result in comparable results for the structural analysis.

[12] The insignificance of the interaction terms led Irwin and Terviö (2002) to drop the interaction terms in their construction of the instrument. I show later that despite their insignificance in the bilateral trade estimation, the contribute to the strength of the instrument and the robustness of the results in the estimation of the income

Table 2.2 reports the results of the baseline structural analysis, which I call Model 1, as well as the original results from FR and NS in the first four columns. First observation is that the size of the OLS estimate for trade openness in column 5 is comparable to those found in the earlier literature, reported in columns 1 and 3. The same applies to the IV-estimates reported in columns 6 and 7 compared to those in columns 2 and 4, respectively. Also, the results here replicate a feature that FR identified; the estimated coefficients in the IV-analysis are larger than the OLS estimates.

There is ample evidence to conclude that the instrument, predicted total trade share, is a strong instrument for a country's openness to trade as measured by actual total trade share. The correlations between actual total trade share and predicted total trade share reported in columns 6 and 7 are between the correlation coefficient reported by FR and the coefficient

equation.

Table 2.1. Estimating the original bilateral trade equation

	(1)	(2)	(3)	(4)	(5)	(6)
	Original FR-results		NS results			
	Variable	*Interaction*	*Variable*	*Interaction*	*Variable*	*Interaction*
Constant	-6.38***	5.10***	n.r.	0.39	-6.26***	6.69**
	(0.42)	(1.78)	n.r.	(1.37)	(0.60)	(2.62)
$Ln(Distance_{ij})$	-0.85***	0.15	-1.14***	0.60**	-1.11***	0.29
	(0.04)	(0.30)	(0.03)	(0.29)	(0.03)	(0.34)
$Ln(Population_i)$	-0.24***	-0.29	0.14***	-0.21	-0.13***	-0.28**
	(0.03)	(0.18)	(0.02)	(0.15)	(0.02)	(0.14)
$Ln(Population_j)$	0.61***	-0.14	0.96***	-0.22	0.93***	-0.09
	(0.03)	(0.18)	(0.02)	(0.14)	(0.02)	(0.13)
$Ln(Area_i)$	-0.12***	-0.06	-0.16***	-0.03	-0.14***	0.05
	(0.02)	(0.15)	(0.02)	(0.15)	(0.02)	(0.14)
$Ln(Area_j)$	-0.19***	-0.07	-0.23***	0.00	-0.23***	-0.06
	(0.02)	(0.15)	(0.02)	(0.16)	(0.02)	(0.16)
$Sum\, Landlocked_{ij}$	-0.36***	0.33	-0.81***	1.05***	-0.67***	0.16
	(0.08)	(0.33)	(0.06)	(0.20)	(0.05)	(0.18)
N	3,220		8,906		9,757	
R^2	0.36		0.35		0.32	
Root MSE	1.64		n.r.		2.48	

Note: Columns (1) and (2) are the results as reported by FR and columns (3) and (4) the results reported by NS; the reported results are supplemented by the asterisks denoting the significance of the estimated coefficient. "n.r." denotes not reported. The dependent variable is bilateral trade share. The uneven numbered columns with heading 'Variable' report the coefficient on the variable listed while even numbered columns with head 'Interaction' report the coefficient on the variable's interaction with the border indicator. Heteroscedastic robust standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.2. The Income Equation: Comparison with FR and NS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Original FR-results		NS results				
	OLS	IV	OLS	IV	OLS	IV	IV
In-sample prediction	–	*no*	–	*yes*	–	*no*	*yes*
TSH_i	0.82***	2.96**	0.82***	2.59***	0.91***	2.45***	2.74***
	(0.32)	(1.49)	(n.r.)	(0.71)	(0.31)	(0.69)	(0.74)
ln(*Population*)	0.21**	0.35**	0.22 **	0.30**	0.27***	0.38***	0.40***
	(0.10)	(0.15)	(0.09)	(0.14)	(0.10)	(0.13)	(0.14)
ln(*Area*)	-0.05	0.20	-0.05	0.17	-0.09	0.08	0.12
	(0.08)	(0.19)	(0.09)	(0.12)	(0.09)	(0.13)	(0.13)
N	98	98	97	97	98	98	98
R^2	0.11	0.09	0.11	–	0.15	–	–
Root MSE	1.04	1.27	n.r.	n.r.	1.04	1.14	1.18
$Corr(TSH_i, \widehat{TSH_i})$	–	0.62	–	0.75	–	0.70	0.70
1st-stage F-stat	–	8.45	–	35.48	–	25.27	25.20

Note: Columns (1) and (2) are the results as reported by FR and columns (3) and (4) the results reported by NS; the reported results are supplemented by the asterisks denoting the significance of the estimated coefficient. "n.r." denotes not reported. The dependent variable is per capita Real GDP for the year 1985, PWT Mark5.6. In-sample prediction means that the predicted trade openness based on in-sample observations only. The alternative instrument is the predicted trade openness based on the total sample, i.e., including out-of-sample predictions. Heteroscedastic consistent standard errors are in parentheses. All reported standard errors are corrected for the use of generated instrumental variables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The 1st-stage F-statistic is the Kleibergen-Paap *rk* Wald F-statistic, a measure of instrument strength.

reported by NS. For both the instrument using only in-sample predictions, used in column 7, as well as the instrument generated using predictions of bilateral trade across all possible partners, used in column 6, the null-hypothesis of weak instrument cannot be rejected. The reported Kleibergen-Paap *rk* Wald F-statistics, henceforth KP F-statistic, are well above the Stock and Yogo (2005)-threshold of 10.

Table 2.3 reports the results from adding geographic controls to incorporate the Rodriguez and Rodrik (2001)-critique that geography determines income through channels other than trade. For each model I report the results using both the instrument generated using only in-sample predictions and the instrument generated from predictions across all possible partners.

First of all, as expected, the inclusion of controls for other determinants of income that are influenced by or directly related to a country's geography, lowers the estimated coefficient on trade share. Secondly, the positive estimates for trade openness reported in Table 2.2 are robust the inclusion of additional geographic controls when using the instrument predicted in-sample. The same cannot be said for estimated coefficient using the instrument generated using

Table 2.3. The Income Equation using controls: comparing different prediction methods

	(1)	(2)	(3)	(4)	(5)	(6)
	Model (2)		Model (3)		Model (4)	
In-sample prediction	*no*	*yes*	*no*	*yes*	*no*	*yes*
TSH_i	0.46	0.70**	0.64	1.08***	1.07**	1.22***
	(0.38)	(0.34)	(0.42)	(0.38)	(0.51)	(0.44)
$\ln Population_i$	0.10	0.12	0.07	0.11	0.02	0.04
	(0.07)	(0.07)	(0.08)	(0.08)	(0.11)	(0.10)
$\ln Area_i$	-0.10	-0.07	-0.08	-0.03	0.06	0.07
	(0.07)	(0.07)	(0.08)	(0.08)	(0.08)	(0.07)
Distance to Equator	4.19***	4.12***				
	(0.33)	(0.33)				
% Area in tropics			-1.58***	-1.54***		
			(0.17)	(0.17)		
S-Saharan Africa					-1.83***	-1.81***
					(0.21)	(0.21)
Latin America					-0.47*	-0.43*
					(0.25)	(0.23)
East Asia					-0.78**	-0.83**
					(0.37)	(0.35)
N	98	98	98	98	98	98
Root MSE	0.70	0.70	0.74	0.75	0.71	0.71
First-stage regressions (selected results):						
$\widehat{TSH}_i$	7.61***	8.48***	7.67***	8.13***	6.74***	7.84***
	(1.93)	(2.09)	(1.73)	(1.86)	(1.44)	(1.59)
Partial R^2	0.28	0.34	0.29	0.33	0.23	0.31
KP *rk* Wald F-stat	15.51	16.40	19.70	19.09	22.08	24.39

The dependent variable is per capita Real GDP for the year 1985, PWT Mark5.6. In-sample prediction means that the predicted trade openness based on in-sample observations only. The alternative instrument is the predicted trade openness based on the total sample, i.e., including out-of-sample predictions. Heteroscedastic consistent standard errors are in parentheses. All reported standard errors are corrected for the use of generated instrumental variables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The 1st-stage F-statistic is the Kleibergen-Paap *rk* Wald F-statistic, a measure of instrument strength.

predictions across all possible partner countries. It is not robust when used to estimate Model 2 and 3, as reported in columns 1 and 3. Also, the in-sample predicted instrument increases the precision of the estimated coefficient for trade openness.

In contrast to the finding by NS, I find that the strength of the generated instrument is not affected by the prediction method used to construct the predicted trade share, $\widehat{TSH}_i$. The null-hypothesis that the generated instruments are weak is rejected for both generated instruments across all four models. All the KP F-statistic reported are larger than 10. Moreover the size of the KP F-statistic in columns 1, 3 and 5 are not different from the reported KP F-statistics in columns 2, 4 and 6, respectively.

IN conclusion, the significance and the increased precision of the trade's estimated effect on income motivates the use of the in-sample instrument. Furthermore, having demonstrated that the basic results are comparable to those found by FR and NS, I move on to the results from the main analysis.

2.5 Results

The main aim of the analysis is to investigate to what extent the number of covariates in the bilateral trade equation drives the result that trade openness (as measured by trade share) is a positive determinant of income. This section analyses the results from the 2SLS analysis using all 792 instruments generated from all possible 792 specifications of the bilateral trade equation. The size of the estimated coefficients and their t-value allows me to evaluate the occurrence of positive and significance estimated coefficients for trade openness. At the same time the first-stage KP F-statistic is used to evaluate the strength of each generated instrument.

I am interested in the persistence of the result - i.e. the frequency that the estimated coefficient for trade share in the income equation is positive and significant at the 5%-level , and the generated instrument used is strong - as it is an indication that the exact specification of the bilateral trade equation is irrelevant.

Overall results Figure 2.1 is a depiction of the results obtained by regressing income on trade openness using each of our 792 instruments for trade openness in the baseline regression, Model 1.

Panel (a) is a histogram of the size of the estimated coefficients for trade openness while panel (b) plots the size of the estimated coefficients against the number of the covariates in the bilateral trade equation. Immediately one notices that each estimated coefficient is positive. The average size of the estimated coefficients is 3.91 while the minimum and maximum are 0.78 and 16.6, respectively.

Considering the significance of the estimated coefficients, I turn to the results depicted in Panel (c) of Figure 2.1, which plots the associated t-values of the estimated coefficients against the number of covariates in the bilateral trade specification. In combination with panel (a),

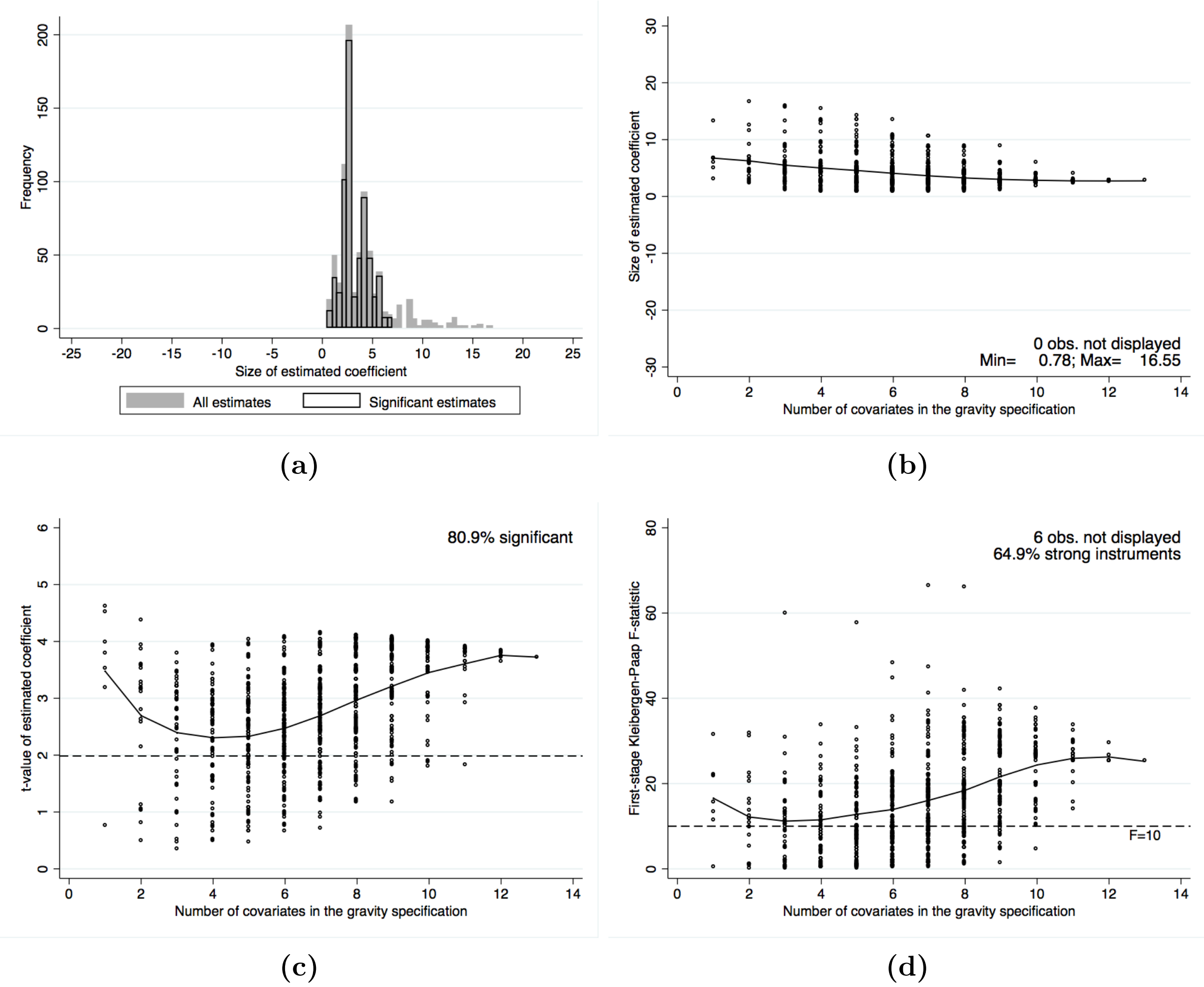


Figure 2.1. Panel (a) is a histogram of all estimated coefficients for trade share, TSH_i, in the income equation. Panels (b), (c), and (d) are scatterplots of the size of the estimated coefficients, the associated t-values and the first-stage KP F-stat, respectively, plotted against the number of covariates in the bilateral trade equation used to generate the instrument for TSH_i.

panel (c) makes it clear that not all of the estimated coefficients are significantly different from zero. As panel (c) reports 80.9%, or 641 of 792, of the estimated coefficients are significantly different from zero at the 5% significance level. It is mostly the larger estimates that are eliminated once one only considers the significant estimates; the average and range of the significant estimated coefficients are 3.31 and 0.84 to 6.91, respectively. However, even then the upper bound of 6.91 implies that a one percent increase in trade openness results in an increase of almost 7% of a country's per capita income; roughly twice the estimate found by FR.

Panel (d) plots the size of the first-stage KP F-statistic an indicator of instrument strength, against the number of covariates in the bilateral trade specification. The figure reports the number of observations not depicted in the upper right hand corner because their value exceeded

80; in this case 6 observations. The horizontal dotted line depicts the Stock and Yogo (2005)-threshold value of 10 for the first-stage KP F-statistic because an instrument that delivers a first-stage KP F-statistic above 10 is considered a strong instrument. As is clearly visible from panel (d) not all estimated coefficients correspond to strong instruments. Panel (d) reports that overall 64.9% of the instruments used can be considered strong.

Of the estimated coefficients that are significant, 74.1% correspond to strong instruments once the size of the first-stage KP F-statistic is taken into account. At almost three quarters, this is a considerable proportion of significant estimated coefficients. A mitigating factor is that discarding estimated coefficients that are the result of weak instruments eliminates more of the larger estimated coefficients than the smaller. The average size of the estimated coefficients drops to 2.94 although the minimum and maximum of 0.85 and 6.91, respectively, are virtually unchanged.

So overall, a considerable proportion, about 60.0%, of the estimates are positive, significant at the 5% level and the result of using a strong instrument in the structural analysis. The estimated effect of trade openness on per capita income is robust to the specification of the bilateral trade equation used.

Discerning patterns associated with the number of covariates Does the fact that two thirds of our variations on the original instrument produce relevant results, mean that the exact specification of bilateral trade equation is irrelevant? If so, what does this mean for the validity of the FR-instrument?

To answer this question the analysis now turns to establishing patterns within the results generated by the 792 variations of the instrument. The focus is on showing the effects of the number of covariates in the bilateral trade equation specification on the size of the coefficient for trade share in the income equation, its significance and the strength of the instrument.

Figure 2.1 panels (b), (c) and (d) plot the size of the IV-estimates, the associated t-values and the first-stage F-statistics, respectively, against the number of covariates in the bilateral trade equation. The plotted line is the average coefficient size, t-value or first-stage KP F-statistic, respectively, for the instruments generated using the same number of covariates in the bilateral trade equation. The data underlying the figure is reported in Table 2.4.

From the line in Figure 2.1b there is a negative relationship between the number of covari-

Table 2.4. Progression as number of covariates increase for in-sample prediction

No. of covariates	1	2	3	4	5	6	7	8	9	10	11	12
No. of specifications	7	21	41	65	96	127	141	126	90	50	21	6
Second-stage regressions (selected results):												
TSH_i	6.746	6.250	5.499	5.007	4.563	4.075	3.627	3.257	3.002	2.843	2.746	2.730
	(3.143)	(3.585)	(3.501)	(3.300)	(3.010)	(2.493)	(2.049)	(1.540)	(1.129)	(0.655)	(0.312)	(0.078)
%-age significant	{85.7}	{76.2}	{70.7}	{66.2}	{69.8}	{76.4}	{80.9}	{88.1}	{93.3}	{94.0}	{95.2}	{100.0}
No. significant & strong	6	16	21	26	36	58	81	89	74	45	20	6
%-age significant & strong	[85.7]	[57.1]	[51.2]	[40.0]	[37.5]	[45.7]	[57.4]	[70.6]	[82.2]	[90.0]	[95.2]	[100]
First-stage regressions (selected results):												
$\widehat{TSH}_i$	23.794	17.579	12.879	9.890	8.093	7.131	6.648	6.599	6.746	6.972	7.149	7.071
	(11.473)	(11.684)	(9.648)	(8.135)	(6.307)	(4.986)	(3.611)	(2.842)	(2.130)	(1.467)	(1.175)	(0.220)
%-age significant	{85.7}	{76.2}	{73.2}	{73.8}	{76.0}	{82.7}	{88.7}	{94.4}	{98.9}	{100.0}	{100.0}	{100.0}
Partial R^2	0.155	0.153	0.141	0.136	0.142	0.155	0.181	0.210	0.244	0.276	0.304	0.321
	(0.150)	(0.157)	(0.143)	(0.133)	(0.131)	(0.125)	(0.121)	(0.110)	(0.099)	(0.078)	(0.055)	(0.021)
$Corr(THS_i, \widehat{TSH}_i)$	0.289	0.385	0.431	0.462	0.497	0.539	0.580	0.616	0.647	0.672	0.691	0.702
KP rk Wald F-stat	16.548	12.150	11.183	11.496	12.808	13.930	16.097	18.425	21.687	24.372	25.918	26.240
%-age strong instruments	<85.7>	<57.1>	<53.7>	<44.6>	<42.7>	<50.4>	<63.1>	<76.2>	<87.8>	<96.0>	<100>	<100>

Notes: The table reports average estimated coefficients for trade openness and predicted trade openness, Partial R^2, Correlation Coefficient and KP rk Wald Fstatistic for each group of instruments generated using the same number of covariates. The standard deviation of these averages is reported in round parentheses. For the estimated coefficients, the percentage of instruments that produce an estimate significant at least at the 5% level is in {curly brackets}. The percentage reported in [square brackets] is the proportion that the estimated coefficients in the second-stage is significant the 5% level while the KP rk Wald F-statistic is greater than 10. The percentage that the KP rk Wald F-stat is greater than 10 is in <angle brackets>.

ates and the size of the IV-estimate for trade openness. The number of covariates influences the average size of the estimated coefficients. At the same time Table 2.4 reports decreasing standard deviations as the number of covariates in the bilateral trade equation is increased. As a result the estimated coefficients for trade openness are more precise when using more covariates in the bilateral trade equation specification used to generate the instrument.

This is corroborated by Figure 2.1c. After an initial drop the average t-value increases as more covariates are used. Also Table 2.4 shows that as number of covariates in the bilateral trade equation specification increases, the proportion of estimated coefficients that are significant at the 5%-significance level, reported in curly brackets, increases. Both indicate that the IV-estimates become more precise as the number of covariates increase.

Figure 2.1d shows that across all groups the average first-stage KP F-statistic is above 10 indicating that the instrument is strong whether is is generated using a single covariate or all 13. After an initial dip in the number of covariates, the average size of the first-stage KP F-statistic increases with the number of covariates used. This trend is corroborated by the proportion of strong instruments reported in angle brackets in the bottom row of Table 2.4. The proportion considered strong increases as does the average of the first-stage F-statistic. Using more covariates in the bilateral trade equation to generate the instrument increases the strength of the instrument.

Given these trends, I now turn to the proportion of significant IV-estimates whose corresponding first-stage KP F-statistic is above 10. These are reported in square brackets in Table 2.4. The difference between these proportions and the proportion of significant estimates (in curly brackets in the third row of the second-stage regression results) indicates that within each subset of estimates not all significant IV-estimates are generated using strong instruments. At the same time Table 2.4 reports a difference of the proportion significant estimates using strong instruments (in square brackets) and the proportion of estimates produced using strong instruments (in angle brackets in the bottom row of the Table) so not all estimates produced using strong instruments are significant. Both of these observations are consistent with the observed characteristics for all 792 instruments. And more importantly, both observations also do not detract from the overall trend that more covariates in the bilateral trade equation leads to more significant results using strong instruments is clearly visible.

The results are encouraging because they are robust to dropping singular covariates from the bilateral trade specification. These results are as one would expect. Using more covariates in a particular bilateral trade equation specification means that, potentially, more of the variation in actual bilateral trade share is explained. This leads to predicted bilateral trade share being a closer approximation to actual bilateral trade share. It should therefore also lead to a higher correlation between the sum of predicted bilateral trade shares for each country i and that country's actual trade share. The selected first-stage results in Table 2.4 provide evidence for this. The coefficient on the instrument in the first-stage is more precisely estimated and more often significant as the number of covariates in the specification used to generate it increases. Also, the average correlation coefficient between actual trade openness and the instrument, as well as the average Partial R^2 increase as the number of covariates used increases. The overfitting of the endogenous regressor as a result of using too many covariates in the specification of the bilateral trade equation is not a concern. Figure 2.1 as well as Table 2.4 show a gradual progression of increasing proportion of significant estimates, increasing precision of the estimated coefficient, as well as increasing instrument strength as the number of covariates increase.

It is not all good news, though. Table 2.4 reports that for any group of instruments with the same number of covariates used to generate the instrument, at least two thirds of the estimated coefficients are significant at the 5%-level. So even few random covariates produce significant results. In the extreme, Table 2.4 column 1 reports that of the 7 instruments generated using one covariate, 6 result in a significant positive estimate for trade share in the income regression. In all these six cases the instrument is strong. Given that the gravity model relates the volume of bilateral trade to 3 elements, countries' size, distance and multilateral resistance to trade, one would expect that a singular covariate is not sufficient to generate a strong instrument for trade share and produces significant results. This is supported by the reported average Partial R^2 and average correlation coefficient between trade share and the predicted trade share for the instruments generated using a single covariate. Comparing the Partial R^2 and correlation coefficient in column 1 of Table 2.4 to those reported in column 12 or the correlation coefficient reported in column 7 of Table 2.2, one sees that both are a fraction of the value reported for the more comprehensive specification of the bilateral trade equation. This is an indication that the instrument generated using the single covariate only captures a small proportion of the exogenous variation of trade share.

The fact that one covariate is enough for a significant result using a strong instrument, is puzzling. Although there is no requirements regarding the minimal number of covariates, one can argue that a single covariate in the bilateral trade equation does not adequately reflect the gravity model of trade, the foundation for the use of the FR-instrument. One could make an exception for bilateral distance, arguably one of the most direct measure of proximity between two countries. Distance is also the foundation for the generated instrument used by Feyrer (2009a). Yet, my results show that the instrument generated based on distance alone produces insignificant results and is weak. Finding out why could be a further avenue of research.

Including additional controls to the income equation Given that there are other channels through which geography affects income besides trade, it is necessary to add additional controls to the equation of interest. Section 2.4.2 demonstrates the validity of this argument. The additional controls decrease the estimated effect of trade on income while estimated coefficient of the geographic controls are also significant.

This section discusses the results of including these additional controls. We use the same 792 instruments as before but estimate equation 2.7 which includes different sets of additional geographic controls, $\mathbf{X_i}$, used by NS. I limit the discussion here to the same three models discussed earlier.

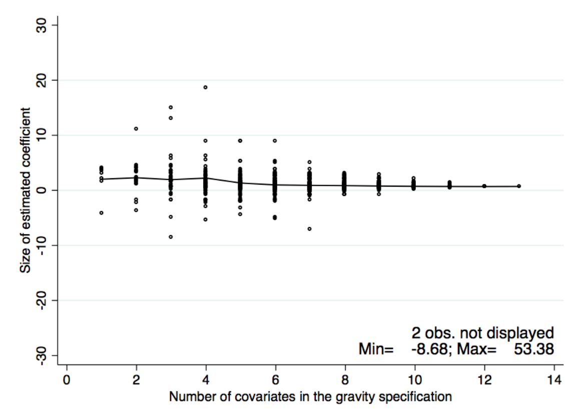
The results from including additional controls in the structural regressions are depicted in Figures 2.2 and 2.3. Figure 2.2 plots the size of the IV-estimates against the number of covariates used in the bilateral trade equation to generate the instrument and is comparable to the scatterplot in panel (b) of Figure 2.1. The associated t-values and first-stage KP F-statistic are shown in the left hand side (LHS) and right hand side (RHS), respectively, of each panel in Figure 2.3. The figures for the remaining 10 models can be found in the Appendix 2D.

Once geographic controls are added to the equation of interest the average size of the IV-estimate for all 792 instruments is lower than without controls. The averages of 1.13 for Model 2 in panel (a), 1.65 for Model 3 in panel (b) and 1.58 for Model 4 in panel (c) of Figure 2.2 are less than half of the average for Model 1. This is as expected since Table 2.3 in Section 2.4.2 has shown that the IV-estimates are corrected downwards as additional geographic controls are added. This downward correction is the reason that some of the 792 instruments now produce IV-estimates for trade openness that are negative. The proportion is limited; at most 10.7% of the estimates are negative for Model 2 in panel (a) while only 4.8% and 3.5% of the IV-estimates for Model 3 and 4, respectively, are negative. Once only IV-estimates significant at the 5%-significance level are considered all estimates are positive. At the same time, the reported ranges in each panel are larger than the reported range for the structural analysis without additional geographic controls in panel (b) of Figure 2.1. On average though, the IV-estimates for each group are clearly positive as the plot in Figure 2.2 shows.

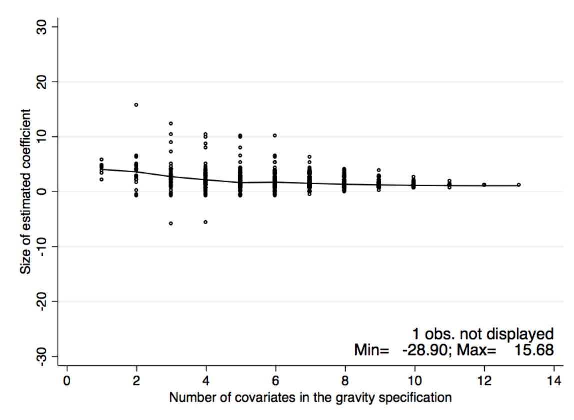
Does adding additional controls affect the significance of the IV-estimates?

The answer is yes. The addition of additional controls lowers the proportion of IV-estimates that are significant at the 5% significance level. For Model 1 this proportion is 80.9% compared to 42.7%, 54.4% and 58.6% reported in the LHS panels of Figure 2.3. This is as expected given that on average the size of the estimated coefficients has dropped.

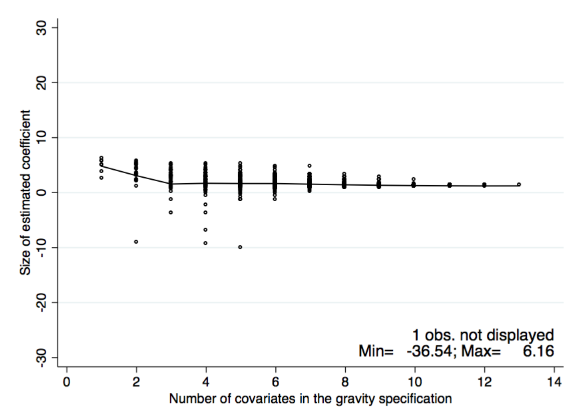
Overall, the trend identified for Model 1 in the previous subparagraph is also visible in the LHS panels of Figure 2.3. As the number of covariates in the bilateral trade equation increases , the average t-value and proportion of significant estimates



(a) Model 2: Distance to the Equator

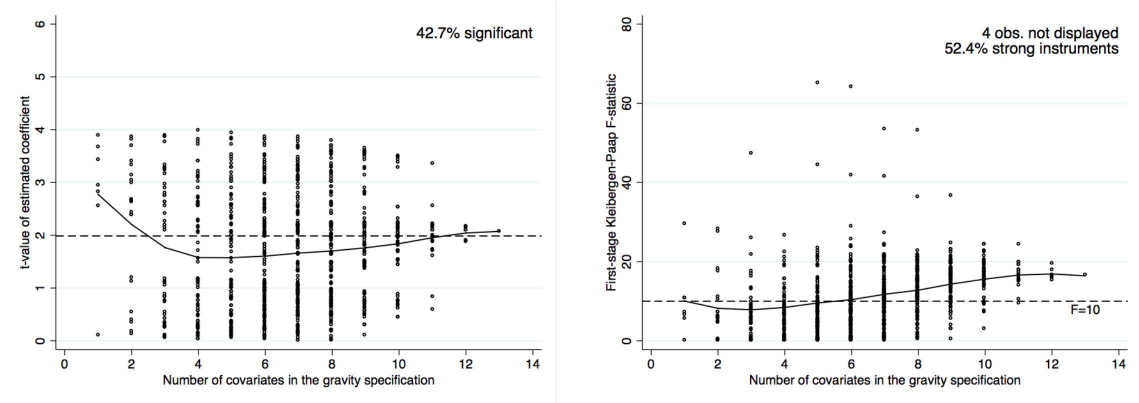


(b) Model 3: % Area in the Tropics

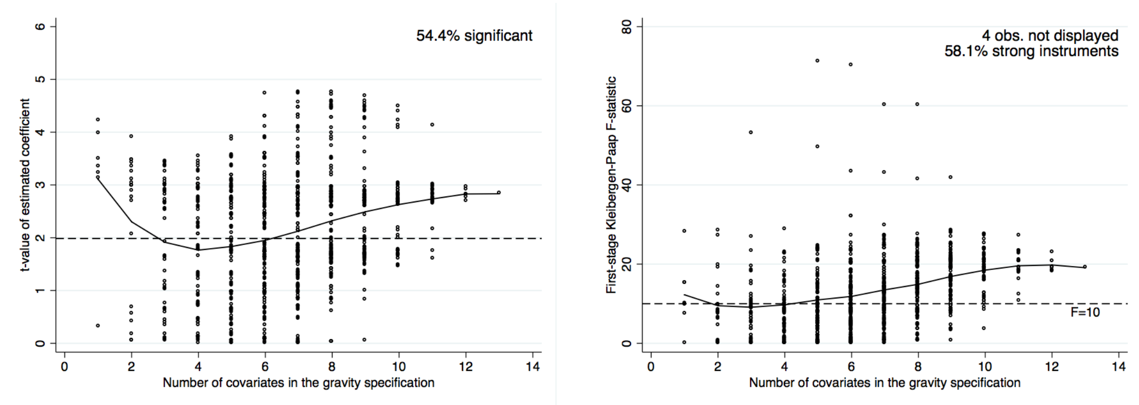


(c) Model 4: Regional Dummies

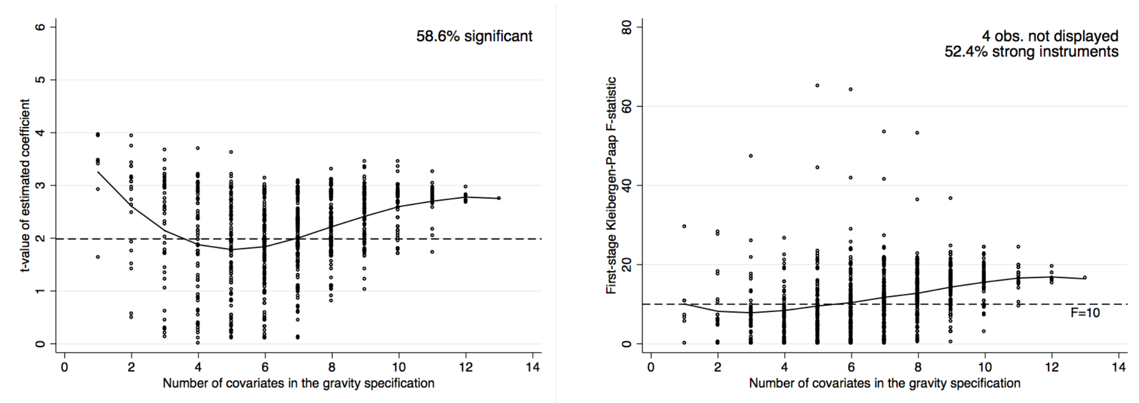
Figure 2.2. Each panel depicts a scatterplot of the size of the estimated coefficients for trade share, TSH_i, plotted against the number of covariates in the bilateral trade equation used to generate the instrument for TSH_i. The set of additional geographic controls used in the regression are listed at the bottom of the panel.



(a) Model 2: Distance to the Equator



(b) Model 3: % Area in the Tropics



(c) Model 4: Regional Dummies

Figure 2.3. Each panel depicts a scatterplot of t-values (LHS) and first-stage KP F-statistic (RHS), associated with the estimated coefficients in Figure 2.2, plotted against the number of covariates in the bilateral trade equation used to generate the instrument for TSH_i. The set of additional geographic controls used in the regression are listed at the bottom of the panel.

increases as well. Also the earlier observation that in 6 out of 7 instances where a singular covariate is used to generate the instrument, leads to significant estimates for trade share and strong instruments, holds.

Regarding instrument strength, the plots on RHS of each panel in Figure 2.3 indicate that at least half of the instruments are strong instruments. And as before, the plotted averages show that as the number of covariates increase the strength of the instrument improves. The only difference with Model 1 is that a smaller proportion of instruments using a single covariate is strong, so a larger proportion of results will be discarded.

In sum, the earlier results and conclusions hold once I control for other channels through which geography affects income in any structural regression using the FR-approach. Results are still robust to small changes in the specification and the overall progression in size and significance of estimates as well as instrument strength is gradual as the number of covariates in the specification is increased.

The anomaly identified earlier for the baseline model is also robust to the inclusion of controls. Almost all instruments generated using a single covariate in the bilateral trade equation specification, produce significant and positive estimated coefficients for trade share. Despite Figure 2.3 demonstrating that once additional controls are used most of these instruments cannot be considered a strong instrument for trade, the anomaly remains striking.

Extending the set of covariates Figure 2.4 shows the results of adding three new covariates to the original FR set of covariates. The number of instruments and hence observations is now extended to 6,343.

The histogram of all IV-estimates in panel (a) and the scatterplot of all the IV-estimates against the number of covariates used in panel (b), show that some IV-estimates are negative. This proportion is negligible, only 1.6% of the IV-estimates are negative and none of these are significant. The overall average size of the estimated coefficients is 5.43, which is larger than the average of 3.91 reported for the original FR set of covariates. This is not surprising given that the range reported in panel (b) of Figure 2.4 is much larger than that reported in panel (b) of Figure 2.1.

Like the original set of covariates a considerable proportion, 69.8%, of all IV-estimates are significant at the 5% significance level. Also, the average of the estimated coefficient drops to 3.67 once only significant estimates are considered, a reflection of the narrowing of the range of coefficient; the minimum 0.76 and the maximum is 12.70. Coefficients with extreme values are not significant.

With a proportion of 51.7% of IV-estimates having a KP F-stat above 10, just about half of the instruments generated are strong instruments. Most of these instruments (92.3%) produce significant IV-estimates. The proportion of significant estimates and strong instruments is slightly lower than this, 47.8% of all estimated coefficients. Although this proportion is considerably lower than for the original set of covariates where 60% of the instruments are strong and produce significant IV-estimates, the average size of the coefficient of this group of IV-estimates is 3.03, not significantly different from the average coefficient of 2.94 reported for Model 1 using the original FR set of covariates.

Panels (b) through (d) of Figure 2.4 show what happens to the size, significance of the IV-estimates as well as the strength of the instrument as the number of covariates is increased

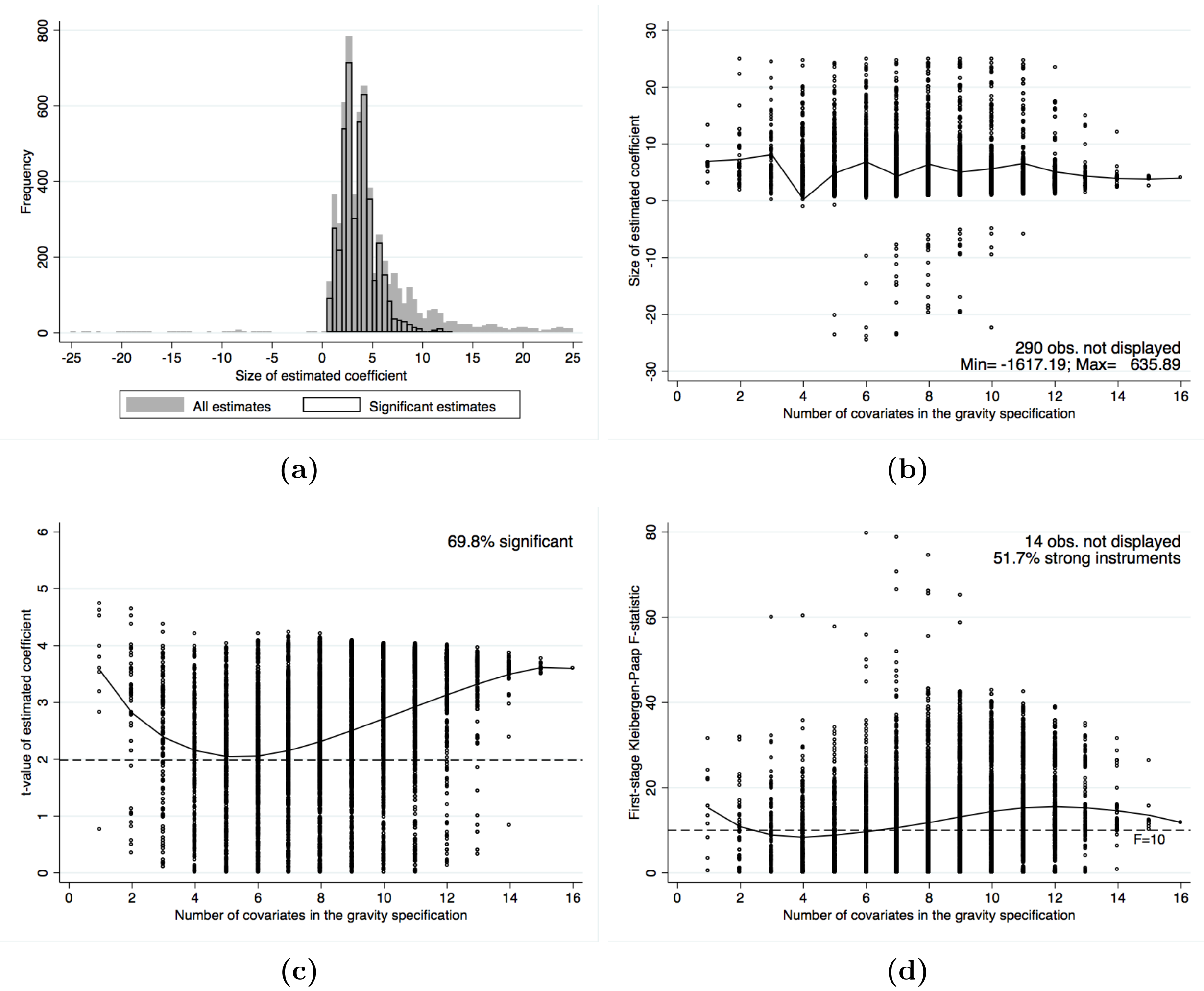


Figure 2.4. Panel (a) is a histogram of all estimated coefficients for trade share, TSH_i, in the income equation. Panels (b), (c), and (d) are scatterplots of the size of the estimated coefficients, the associated t-values and the first-stage KP F-stat, respectively, plotted against the number of covariates in the bilateral trade equation used to generate the instrument for TSH_i.

in the bilateral trade specification is increased. The patterns are similar to those in Figure 2.1. More covariates lead to estimated coefficients that are on average smaller in size while also more precise as indicated by the increase in the average t-value for each subset of instruments. As for the original set of covariates, the average KP F-stat decreases slightly before it increases again. The average is above 10 once 7 or more covariates are used, although overall much lower as the average KP F-stat does not reach the value of 20.

Used individually to generate the instrument for trade, all three 'new' covariates produce IV-estimates that significant at the 1% significance level. However only the dummy variable for common official language produces a strong instrument, which is supported by evidence that linguistic factors have a large effect on the volume of bilateral trade (Melitz and Toubal, 2014).

In sum, extending the set of covariates does not significantly alter the findings presented using the original FR set of covariates.

2.6 Conclusion

The validity of any instrument used in IV-analysis depends on the credibility of the arguments used to motivate that the instrument captures the exogenous variation of the endogenous regressor. Murray (2006) advocates being creative when motivating an instrument's use by appealing to intuition, and thoroughly laying theoretical foundations as well as demonstrating empirical evidence of a strong relationship between endogenous regressor and the instrument.

The intuitive appeal of the FR-instrument is evident from its ubiquitous use. Combined with the gravity model's theoretical foundations and its empirical success, it seems that these conditions are met and the use of the instrument should be undisputed.

Throughout the literature, different specifications of the bilateral trade equation have been utilized to instrument for trade. And although these variations are well-motivated, the fact that their effect on the original results found by FR is minimal, i.e. trade's effect on income, gives us pause.

This paper aims to identify the effect different instruments will have on the size and significance of the estimated coefficient for trade share, as well as the strength of the instrument.

The results presented here show that trade's effect on income using the generated instrument are very robust to the variations in the specification of the bilateral trade equation used. All instruments produce estimated coefficients for trade share in the structural analysis that are positive and around 80% of those are significant at 5% significance level. Furthermore, about 60% of all the estimated coefficients are significant and produced using a strong instrument.

Specifications that do not deviate too much from the original do little to change the results generated in the structural regression. The estimated coefficients for trade's effect on income continue to be significant while the instrument is strong. This can be seen as an indicator that the model used to generate the instrument is not overfitted and therefore the instrument does not bias the estimates of the variable of interest, trade's effect on income. It's also an argument that it's not a single covariate that is driving the results found and therefore not invalidating the FR-instrument, a counter to the critique by Bazzi and Clemens (2013).

However, large variations from the original specification proposed by FR still produce significant estimated coefficients while the instrument used is deemed strong. In 6 out of 7 instances when the instrument used is generated by using a single covariate in the bilateral trade equation, the estimated coefficient for trade share is significantly positive. The one covariate that does not produce significant results is bilateral distance, which is counterintuitive to the gravity model of trade. Another reason that the persistence is concerning is that a specification with a single covariate does not resemble the gravity model of trade. It is this persistence of positive, significant estimates that is most puzzling and a possible avenue for further research.

References

Acemoglu, D., Johnson, S. and Robinson, J. A. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation, *The American Economic Review* **91**(5): 1369–1401.

Amiti, M. and Konings, J. (2007). Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia, *American Economic Review* **97**(5): 1611–1638.

Anderson, J. E. (2011). The Gravity Model, *Annual Review of Economics* **3**(1): 133–160.

Anderson, J. E. and van Wincoop, E. (2003). Gravity with Gravitas: A Solution to the Border Puzzle., *American Economic Review* **93**(1): 170–192.

Bazzi, S. and Clemens, M. A. (2013). Blunt Instruments: Avoiding Common Pitfalls in Identifying the Causes of Economic Growth, *American Economic Journal: Macroeconomics* **5**(2): 152–186.

Coe, D. T. and Helpman, E. (1995). International R&D spillovers, *European Economic Review* **39**(5): 859–887.

Easterly, W. and Levine, R. (1997). Africa's Growth Tragedy: Policies and Ethnic Divisions, *The Quarterly Journal of Economics* **112**(4): 1203–1250.

Easterly, W. and Levine, R. (2003). Tropics, germs, and crops: how endowments influence economic development, *Journal of Monetary Economics* **50**(1): 3–39.

Feenstra, R. C., Madani, D., Yang, T.-H. and Liang, C.-Y. (1999). Testing endogenous growth in South Korea and Taiwan, *Journal of Development Economics* **60**(2): 317–341.

Feenstra, R. and Kee, H. L. (2008). Export variety and country productivity: Estimating the monopolistic competition model with endogenous productivity, *Journal of International Economics* **74**(2): 500–518.

Feyrer, J. (2009a). Distance, Trade, and Income - The 1967 to 1975 Closing of the Suez Canal as a Natural Experiment, *Working Paper 15557*, National Bureau of Economic Research.

Feyrer, J. (2009b). Trade and Income – Exploiting Time Series in Geography, *Working Paper 14910*, National Bureau of Economic Research.

Frankel, J. A. and Romer, D. (1999). Does Trade Cause Growth?, *American Economic Review* **89**(3): 379–399.

Gallup, J. L., Sachs, J. D. and Mellinger, A. D. (1999). Geography and Economic Development, *International Regional Science Review* **22**(2): 179–232.

Glick, R. and Taylor, A. M. (2010). Collateral Damage: Trade Disruption and the Economic Impact of War, *Review of Economics and Statistics* **92**(1): 102–127.

Hall, R. E. and Jones, C. I. (1999). Why Do Some Countries Produce So Much More Output Per Worker Than Others?, *The Quarterly Journal of Economics* **114**(1): 83–116.

Head, K., Mayer, T. and Ries, J. (2010). The erosion of colonial trade linkages after independence, *Journal of International Economics* **81**(1): 1–14.

Heston, A. and Summers, R. (1991). The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988, *Quarterly Journal of Economics* **106**(2): 327–368.

International Monetary Fund (n.d.). Direction of Trade Statistics.

Irwin, D. A. and Terviö, M. (2002). Does trade raise income?: Evidence from the twentieth century, *Journal of International Economics* **58**(1): 1–18.

Knack, S. and Keefer, P. (1995). Institutions and economic performance: cross-country tests using alternative insti- tutional measures, *Economics & Politics* **7**(3): 207–227.

La Porta, R., Lopez-de Silanes, F. and Shleifer, A. (2008). The Economic Consequences of Legal Origins, *Journal of Economic Literature* **46**(2): 285–332.

Madsen, J. B. (2016). Barriers to Prosperity: Parasitic and Infectious Diseases, IQ, and Economic Development, *World Development* **78**: 172–187.

Mankiw, N. G., Romer, D. and Weil, D. N. (1992). A Contribution to the Empirics of Economic Growth, *The Quarterly Journal of Economics* **107**(2): 407–437.

Mayer, T. and Zignago, S. (2011). Notes on CEPII's distances measures: the GeoDist Database, *Working Paper 2011-25*, CEPII.

Melitz, J. and Toubal, F. (2014). Native language, spoken language, translation and trade, *Journal of International Economics* **93**(2): 351–363.

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity, *Econometrica* **71**(6): 1695–1725.

Murray, M. P. (2006). Avoiding Invalid Instruments and Coping with Weak Instruments, *Journal of Economic Perspectives* **20**(4): 111–132.

Noguer, M. and Siscart, M. (2005). Trade raises income: a precise and robust result, *Journal of International Economics* **65**(2): 447–460.

Ortega, F. and Peri, G. (2014). Openness and income: The roles of trade and migration, *Journal of International Economics* **92**(2): 231–251.

Polity IV Project (2014). Political Regime Characteristics and Transitions, 1800-2015.

Rivera-Batiz, L. A. and Romer, P. M. (1991). Economic integration and endogenous growth, *Quarterly Journal of Economics* **106**(2): 531.

Rodriguez, F. and Rodrik, D. (2001). Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence, *NBER Macroeconomics Annual 2000*, Vol. 15, MIT PRess, pp. 261–338.

Rodrik, D., Subramanian, A. and Trebbi, F. (2004). Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development, *Journal of Economic Growth* **9**(2): 131–165.

Roodman, D. (2009). A Note on the Theme of Too Many Instruments, *Oxford Bulletin of Economics & Statistics* **71**(1): 135–158.

Stock, J. H. and Yogo, M. (2005). Testing for weak instruments in linear IV regression, *in* J. H. Stock and D. Andrews (eds), *Identification and Inference for Econometric Models: A Festschrift in Honor of Thomas J. Rothenberg*, Cambridge University Press, Cambridge, pp. 80–108 (Ch.5).

World Bank (n.d.). World Development Indicators.

2A Data Description

Bilateral data set

The bilateral data set includes bilateral data for the 98 countries from the Mankiw et al. (1992)-sample and 162 partner countries, i.e. each country has 161 partners.

The 98 countries in the Mankiw sample include: Algeria, Angola, Argentina, Australia, Austria, Bangladesh, Belgium, Benin, Bolivia, **Botswana**, Brazil, Burkina Faso, Burundi, Cameroon, Canada, Central African Republic, Chad, Chile, Colombia, Congo, Costa Rica, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Finland, France, Germany (unified), Ghana, Greece, Guatemala, Haiti, Honduras, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Ivory Coast, Jamaica, Japan, Jordan, Kenya, South Korea, Liberia, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Morocco, Mozambique, Myanmar, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Portugal, Rwanda, Senegal, Sierra Leone, Singapore, Somalia, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syria, Tanzania, Thailand, Togo, Trinidad & Tobago, Tunisia, Turkey, U.K., U.S.A., Uganda, Uruguay, Venezuela, Zaire, Zambia and Zimbabwe.

The 162 partner countries include the 98 countries listed in the previous paragraph and: Afghanistan, Albania, Bahamas, Bahrain, Barbados, Belize, Bhutan*, Brunei Darussalam, Bulgaria, Cambodia, Cape Verde, China, Comoros, Cuba, Cyprus, Czechoslovakia, Djibouti, East Timor*, Eritrea*, Equatorial Guinea, Fiji, French Polynesia*, Gabon, Gambia, Guinea, Guinea-Bissau, Guyana, Hungary, Iceland, Iran, Iraq, Kuwait, Laos, Lebanon, Libya, **Lesotho**, Luxembourg, Maldives, Malta, Mongolia, **Namibia**, New Caledonia, North Korea, Oman, Poland, Puerto Rico*, Qatar, Reunion, Romania, Sao Tome and Principe, Saudi Arabia, Solomon Islands, St.Lucia, St.Vincent & Grenadines, Suriname, **Swaziland**, Taiwan*, U.S.S.R., United Arab Emirates, Vanuatu, Vietnam, Western Samoa, Yemen and Yugoslavia.

In the country lists above, countries in bold font are non-reporting in the DOTS but enter our dataset because of the symmetry imposed on bilateral trade flows. There is no record of bilateral trade for countries that are starred.

Bilateral trade data from the DOTS for the year 1985 is used to construct symmetric bilateral trade flows. In order to ensure symmetry within each dyad, i.e. that bilateral trade from A to B equals bilateral trade from B to A, the measure of bilateral trade for each of dyad is the sum of bilateral exports and bilateral imports of the country reporting both bilateral flows. If both countries in a dyad report both bilateral exports and bilateral imports, the highest sum reported is taken as the measure of bilateral trade for the dyad. The values of bilateral exports and bilateral imports, whose sum is taken as the measure of bilateral trade for the dyad, are attributed to the reporting country. Then the value of the reporting country's exports are multiplied by 1.1 (to account for cost, insurance and freight) and taken as the value of the partner's imports. At the same time the value of the reporting country's imports are divided by 1.1 and taken as the measure of the partner's exports.

Bilateral trade share is calculated by dividing bilateral trade in nominal terms by the destination country's GDP. The latter is the product of per capita real GDP (base year 1985) and a country's population both from the Penn World Tables (PWT) Mark 5.6.

The data set is completed with data on area, bilateral distance, border and landlocked status from the CEPII *GeoDist* database. Population data are from the PWT Mark5.6 and, when missing, the World Development Indicators (WDI). The WDI measure is highly correlated with the measure from the PWT Mark5.6. Also, the original source for the PWT data is the World Bank World Tables (the WDI's predecessor).

Country data set

Real income per capita, trade openness as well as population data are taken from PWT Mark5.6. Area is sourced from CEPII *GeoDist*. PWT v9.0 is the source for Expenditure-side and Output-side GDP at current PPP's, and the real export share and import share for 1985. The measure of GDP per capita is constructed by dividing each GDP measure by population (as reported in PWT Mark5.6). The country's real openness is the sum of its real export share and (the absolute value) of its real import share.

Data on the percentage of land or population in the tropics, and continents is from the Centre for International Development (CID). Latitude and distance to the equator are sourced from the CEPII. Legal origin is from La Porta et al. (1998) and, when missing, from the CIA World Factbook. The index of ethno-linguistic fractionalization is from Easterly and Levine (1997). Data on constraint on executive is from the Polity IV Project. Finally, data on corruption and the quality of governance come from the International Country Risky Guide (ICRG) provided by the Political Risk Services Group.

Country-specific notes

For Germany and Yemen the reported trade for their constituent states in 1985 is aggregated. To get the bilateral trade data for Belgium, Luxembourg and South Africa information on trade of their corresponding aggregate in 1985 is combined with their own trade in the first year in which they record it (1997 for Belgium and Luxemburg, and 1998 for South Africa).

Geographic data for former Czechoslovakia, former Yugoslavia and the former Soviet Union (all three of which are included in PWT v5.6) is constructed using data observations of their constituent countries. Area is the sum of the areas of former constituent countries. Latitudinal coordinates are the coordinates of the former capitals, i.e. Moscow for the USSR. Bilateral distance with any third country is the population-weighted sum of bilateral distances of its constituent countries with that country[13]. The landlocked and common border dummies are constructed from consulting old maps online.

Table A1. Overview of variables

Variable	Description	Source
Real GDP per capita	Real GDP per capita, chain weighted, US$, base year=1985.	PWT Mark5.6
Population	Total population.	PWT Mark5.6 and WDI
Area	Area in km2.	CEPII *GeoDist*

[13]For instance, the bilateral distance between Czechoslovakia and France is the population-weighted sum of bilateral distances between the Czech Republic and France and between the Slovak Republic and France.

Table A1. Overview of variables

Variable	Description	Source
Bilateral Trade	Sum of bilateral exports and imports, in millions of US$.	DOTS
Distance	Distance between two main cities, weighted for the geographic distribution of the population within the country, in km.	CEPII *GeoDist*
Landlocked	Dummy variable set equal to 1 for landlocked countries.	CEPII *GeoDist*
Border	Dummy variable set equal to 1 for country pairs sharing a border.	CEPII *GeoDist*
Latitude	Calculated as the latitude of the main city, scaled to take values between -1 and 1.	CEPII *GeoDist*
Distance to the equator	Calculated using the absolute value of the latitude, scaled to take values between 0 and 1.	CEPII *GeoDist*
% Land in tropics	The percentage of land area located in the tropics.	CID
Continental Dummies	Dummy variables for Latin America, Sub-Saharan Africa, and East Asia.	CID
% Population in tropics	The percentage of the population living in a tropical area.	CID
ICRG index	An index constructed as the sum of five variables: corruption, bureaucratic quality and rule of law, each multiplied by 5/3, as well as repudiation of contracts and expropriation risk. The index is normalized to vary between 0 and 1.	Policy Risk Services Group
Corruption	Assessment of corruption within the political system; rescaled to take values between 0 and 1.	Policy Risk Services Group
Executive constraint	Index of the extent to which decision making power of the executive is constrained by institutionalized procedure.	PolityIV
Ethno-linguistic fractionalization	Index that measures the probability that two randomly selected people from a given country do not belong to the same ethnolinguistic group.	Easterly and Levine (1997)
Legal origin	Variable that takes on 1 if a country's legal origin is English, 2 if it is French, 3 if it is German and 4 if it is Scandinavian.	La Porta et al. (2008)

2B How 792 specifications are constructed

Table B1. Number of specifications of the bilateral trade equation

		No. of border interaction terms, n							
		0	1	2	3	4	5	6	
No. of geographic covariates, m	1	7							
	2	21	6						
	3	35	30	15					
	4	35	60	60	20				
	5	21	60	90	60	15			
	6	7	30	60	60	30	6		
	7	1	6	6	20	15	6	1	
Total		127						655	**792**

The bilateral trade equation used by FR contains 13 covariates of which seven are geographic variables: distance, population country i, population country j, area country i, area country j, sum of landlocked countries and border. This is the set of geographic variables. The remaining six covariates are the interaction terms of border with every other covariate.

From the set of seven geographic variables, k, it is possible to create 127 unique combinations containing m covariates where $m = [1, k]$ and $k = 7$. The following formula for calculating the number of specifications containing m covariates and no interaction terms, n, i.e. $n = 0$, is:

$$\text{No. of specifications} = \frac{k!}{m! \times (k-m)!}$$

To calculate the number of specifications that border include interaction terms, the formula is adjusted slightly as a result of the conditions for including of interaction terms. The first condition is that interaction terms are only included if the variable border is in the specification. Therefore for every value of m one picks $m-1$ covariates from a set of $k-1$ geographic variables, resulting in the first fraction below that calculates the number of specifications containing border and $m-1$ other geographic covariates. To each of these specifications it is possible to add n interaction terms, where $n = [1, m-1]$. As a result of the condition I impose to only include interaction terms between border and another covariate present in the specification, $m-1$ is the maximum number of border interaction terms that can be added. So, one can select n interaction terms from $m-1$ available interaction terms for each specification that contain m geographic covariates of which 1 is border. Multiplying this second part with the first gives me the number of specifications containing m covariates and n interaction terms, where $n = [1, m-1]$:

$$\text{No. of specifications} = \frac{(k-1)!}{(m-1)! \times [(k-1)-(m-1)]!} \times \frac{(m-1)!}{n! \times (m-1-n)!}$$

2C Replication using additional controls

Table C1. Estimates of the Income Equation using Actual Data: Additional Controls Included

Second-stage results:	**Model (5)**		**Model (6)**		**Model (7)**		**Model (8)**		**Model (9)**	
In-sample prediction	*no*	*yes*	*no*	*yes*	*no*	*yes*	*no*	*yes*	*no*	*yes*
Trade share$_i$	0.693*	1.023***	0.613	1.078***	0.451	0.710**	0.524	0.909***	0.841*	1.110***
	(0.386)	(0.353)	(0.440)	(0.407)	(0.329)	(0.288)	(0.379)	(0.330)	(0.490)	(0.413)
ln $Population_i$	-0.03	0.001	0.067	0.108	0.006	0.028	-0.026	0.01	-0.024	0.017
	(0.077)	(0.081)	(0.085)	(0.088)	(0.066)	(0.066)	(0.073)	(0.076)	(0.097)	(0.090)
ln $Area_i$	0.146**	0.176**	-0.081	-0.033	0.026	0.053	0.06	0.097	0.124*	0.140**
	(0.070)	(0.071)	(0.083)	(0.082)	(0.063)	(0.063)	(0.069)	(0.069)	(0.069)	(0.070)
Latitude$_i$	0.609**	0.568**	0.058	0.01			0.212	0.169	0.296	0.28
	(0.273)	(0.287)	(0.328)	(0.339)			(0.260)	(0.271)	(0.379)	(0.396)
% Population in tropics$_i$	-2.012***	-1.979***			-1.304***	-1.290***	-1.480***	-1.447***	-1.293***	-1.276***
	(0.203)	(0.208)			(0.219)	(0.222)	(0.225)	(0.232)	(0.285)	(0.284)
Distance to equator$_i$					2.483***	2.431***				
					(0.368)	(0.370)				
% Land in tropics$_i$			-1.565***	-1.533***			-0.719***	-0.712***		
			(0.186)	(0.185)			(0.206)	(0.207)		
Sub-Saharan Africa$_i$									-0.865***	-0.839**
									(0.329)	(0.333)
East Asia$_i$									-0.413	-0.529
									(0.394)	(0.374)
Latin America$_i$									-0.123	-0.054
									(0.312)	(0.303)
Observations	98	98	98	98	98	98	98	98	98	98
First-stage regressions:										
$\widehat{T}_i$	8.655***	9.554***	8.853***	9.659***	7.602***	8.487***	8.825***	9.649***	7.364***	8.597***
	(2.216)	(2.302)	(2.211)	(2.294)	(1.935)	(2.091)	(2.222)	(2.327)	(1.787)	(1.831)
Partial R^2	0.31	0.369	0.317	0.374	0.282	0.336	0.315	0.371	0.244	0.328
KP *rk* Wald F-stat	15.253	17.223	16.04	17.734	15.431	16.468	15.774	17.193	16.988	22.057

Note. The dependent variable is log of real GDP per capita reported by PWT Mark 5.6 for the year 1985. Heteroscedastic consistent standard errors are in parentheses. The standard errors in the second-stage are corrected for the errors created from the generated regressors. In-sample prediction means that the predicted trade openness based on in-sample observations only. The alternative instrument is the predicted trade openness based on the total sample, i.e., including out-of-sample predictions. The KP *rk* Wald F-stat is the Kleibergen-Paap *rk* Wald F-statistic. Exogenous variables are included in the first-stage regressions but not shown. *,**, *** Significant at 10, 5 and 1 percent, respectively.

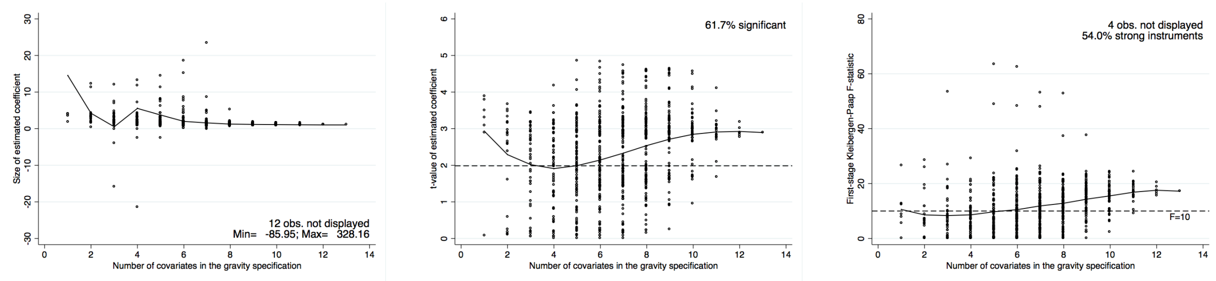
Table C2. Estimates of the Income Equation using Actual Data: Additional Controls Included

Second-stage results:	**Model (10)**		**Model (11)**		**Model (12)**		**Model (13)**		**Model (14)**	
In-sample prediction	*no*	*yes*	*no*	*yes*	*no*	*yes*	*no*	*yes*	*no*	*yes*
Trade share$_i$	.133	.356	.094	.396	.782**	.895***	.773*	1.099***	.823**	1.097***
	(0.351)	(0.322)	(0.402)	(0.346)	(0.306)	(0.284)	(0.406)	(0.377)	(0.393)	(0.352)
Ln population$_i$	-0.066	-0.058	-0.043	-0.034	-0.007	.005	.032	.062	.021	.051
	(0.053)	(0.054)	(0.058)	(0.058)	(0.077)	(0.077)	(0.078)	(0.083)	(0.087)	(0.091)
Ln area$_i$	.074	.108	.066	.112	.132**	.140**	.146*	.178**	.137**	.159**
	(0.070)	(0.069)	(0.083)	(0.077)	(0.059)	(0.060)	(0.076)	(0.077)	(0.069)	(0.070)
Latitude$_i$	.255	.287	.450**	.475**	.500**	.483**	.477*	.426	.322	.258
	(0.189)	(0.198)	(0.221)	(0.224)	(0.209)	(0.213)	(0.278)	(0.289)	(0.323)	(0.335)
% Population in tropics$_i$	-1.499***	-1.527***	-1.622***	-1.647***	-1.268***	-1.261***	-1.715***	-1.661***	-1.944***	-1.915***
	(0.182)	(0.180)	(0.203)	(0.198)	(0.207)	(0.209)	(0.254)	(0.255)	(0.221)	(0.226)
IGRC-Index$_i$	2.425***	2.259***								
	(0.343)	(0.354)								
Corruption$_i$			1.669***	1.520***						
			(0.278)	(0.277)						
Executive constraint$_i$					.210***	.210***				
					(0.027)	(0.028)				
Ethno-ling. fract.$_i$							-0.716**	-0.785**		
							(0.319)	(0.319)		
Legal Origin$_i$									.230*	.255**
									(0.119)	(0.119)
Observations	90	90	90	90	94	94	95	95	96	96
First-stage regressions:										
	6.812***	7.614***	6.996***	8.003***	8.063***	8.949***	8.786***	9.748***	8.895***	9.813***
	(1.708)	(1.903)	(1.679)	(1.842)	(2.675)	(2.859)	(2.204)	(2.297)	(2.220)	(2.277)
Partial R^2	.238	.279	.228	.281	.273	.328	.319	.383	.334	.399
KP *rk* Wald *F*-stat	15.905	16.017	17.363	18.884	9.084	9.797	15.89	18.013	16.053	18.578

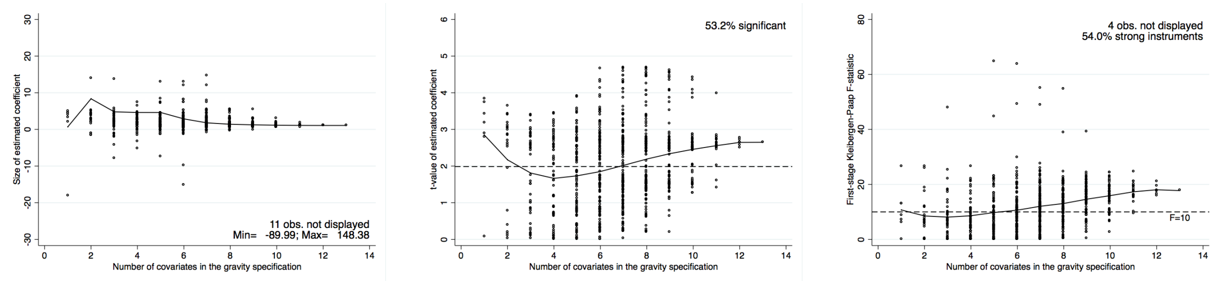
Note. The dependent variable is log of real GDP per capita reported by PWT Mark 5.6 for the year 1985. Heteroscedastic consistent standard errors are in parentheses. The standard errors in the second-stage are corrected for the errors created from the generated regressors. In-sample prediction means that the predicted trade openness based on in-sample observations only. The alternative instrument is the predicted trade openness based on the total sample, i.e., including out-of-sample predictions. The KP *rk* Wald *F*-stat is the Kleibergen-Paap *rk* Wald *F*-statistic. Exogenous variables are included in the first-stage regressions but not shown. *,**, *** Significant at 10, 5 and 1 percent, respectively.

2D Robustness: including additional controls

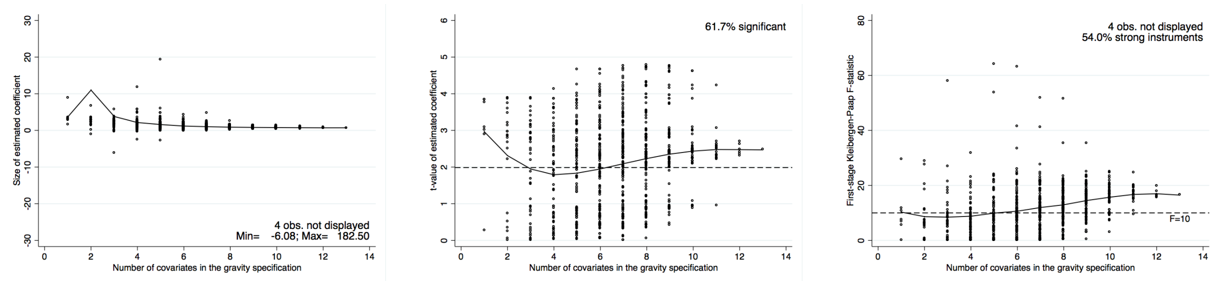
The following figures are in addition to the figure discussed in the third paragraph of Section 2.5 to Figures 2.2 and 2.3. Each panel shows the remaining models, 5 through 14, used by NS.



(a) Model 5: Latitude and % Population in the Tropics

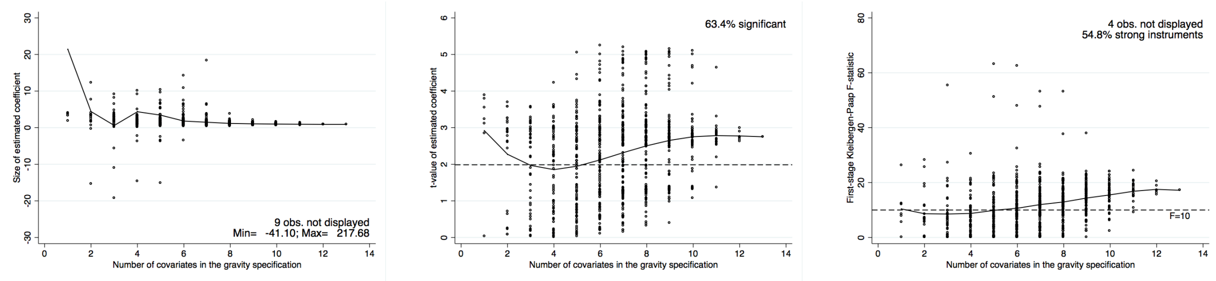


(b) Model 6: Latitude and % Area in the Tropics

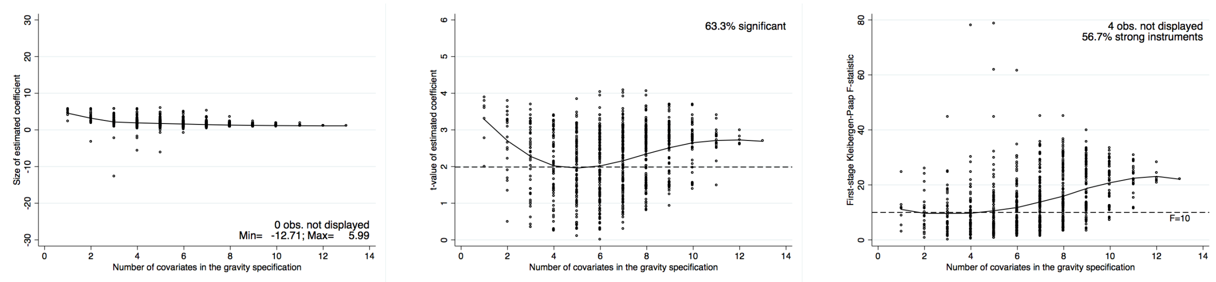


(c) Model 7: % Population in Tropics and Distance to the Equator

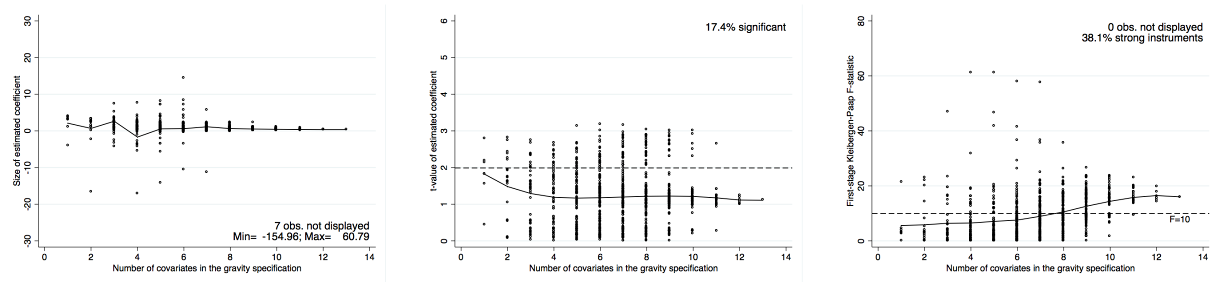
Figure D1. Plots of IV-estimates (lhs), corresponding t-values (center) and first-stage Kleibergen Paap *rk* Wald *F*-statistics (rhs) against the number of covariates in the bilateral trade equation used to generate the instrument. The additional controls are added to the baseline income equation are listed in the caption of each panel.



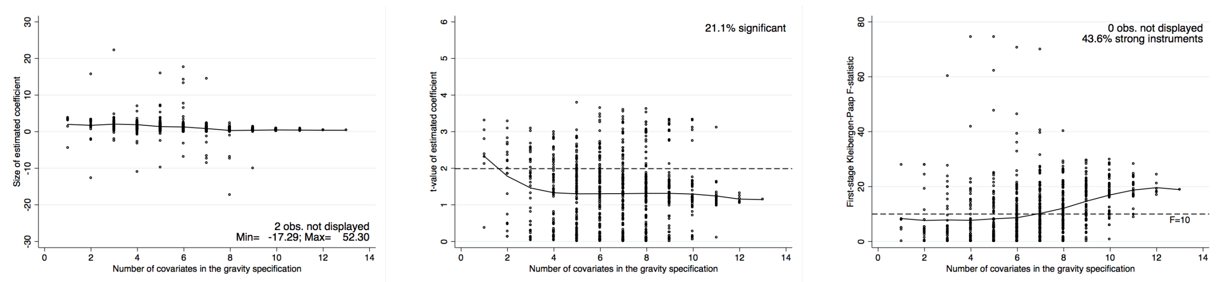
(a) Model 8: Latitude, % Population in Tropics and % Area in Tropics



(b) Model 9: Latitude, % Population in the Tropics and Regional Dummies

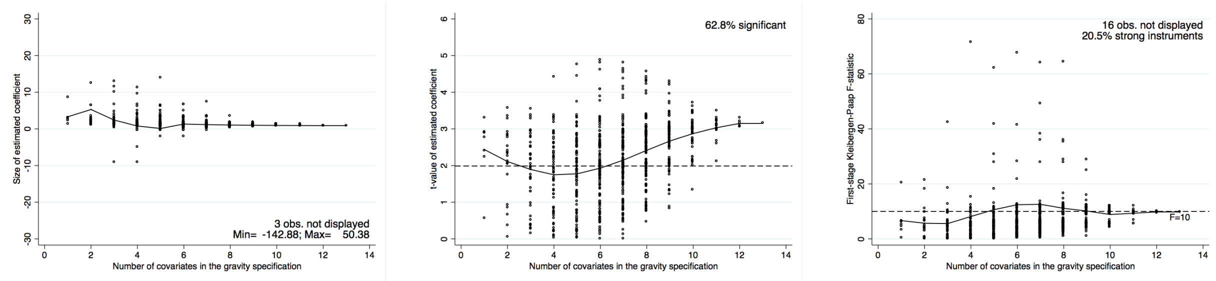


(c) Model 10: Latitude, % Population in the Tropics and ICRG-Index

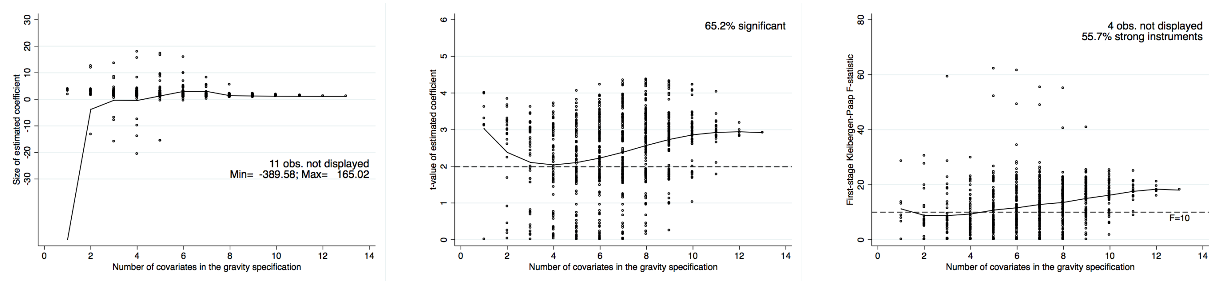


(d) Model 11: Latitude, % Population in the Tropics and Corruption

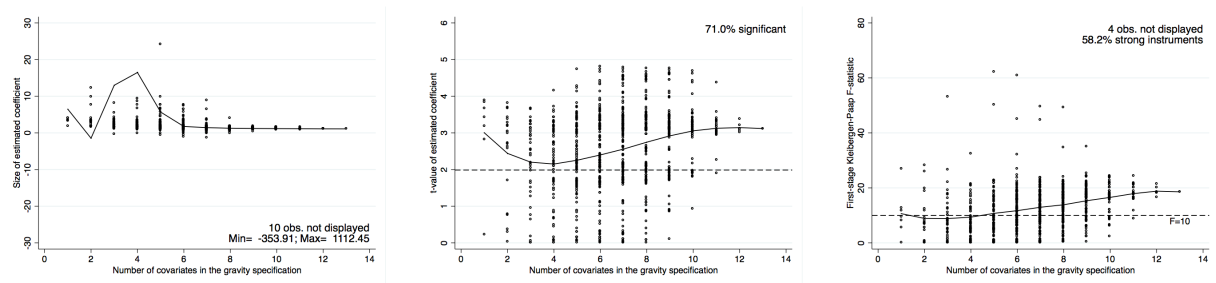
Figure D2. Plots of IV-estimates (lhs), corresponding t-values (center) and first-stage Kleibergen Paap *rk* Wald *F*-statistics (rhs) against the number of covariates in the bilateral trade equation used to generate the instrument. The additional controls are added to the baseline income equation are listed in the caption of each panel.



(a) Model 12: Latitude, % Population in the Tropics and Executive Constraint



(b) Model 13: Latitude, % Population in the Tropics and Ethno-Linguistic Fractionalization



(c) Model 14: Latitude, % Population in the Tropics and Legal Origin

Figure D3. Plots of IV-estimates (lhs), corresponding t-values (center) and first-stage Kleibergen Paap *rk* Wald *F*-statistics (rhs) against the number of covariates in the bilateral trade equation used to generate the instrument. The additional controls are added to the baseline income equation are listed in the caption of each panel.

Chapter 3

Does Trade Matter For Growth When The Geographical Instruments Are Randomly Generated?

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Abstract
In their highly influential paper 'Does Trade Cause Growth?,' Frankel and Romer (1999) (FR) estimate a trade equation to predict bilateral trade shares, which are in turn used to construct an instrument for trade openness in income regressions. Several papers have followed the FR approach; however, they rarely state whether out-of-sample predictions of bilateral trade flows are included in the instrument set. Using bilateral trade shares predicted from randomly generated geographical characteristics to form instruments for trade openness, this paper shows that the results are highly sensitive to whether out-of-sample predictions are included in the instrument set. We show analytically and empirically that the coefficient of trade openness in income regressions is severely upward biased when out-of-sample predictions are excluded from the instrument set because the instrument captures the number of trading partners and, therefore, violates the exclusion restriction. Thus, out-of-sample predictions should always be included in the instrument set to eliminate mechanical endogeneity.

JEL: F14, F43, O40
Key words: Trade-growth nexus; Randomly generated instruments; Endogeneity

3.1 Introduction

In their seminal paper Frankel and Romer (1999), (henceforth FR) propose a novel IV approach in which the geographic characteristics of countries are used to construct an instrument for trade in per capita income cross-country regressions. FR use a two-step approach for identification. In the first-step, they generate the instrument. They estimate a trade equation to predict bilateral trade shares based on geographic characteristics that are unrelated to income, such as bilateral distance, common border, size and landlockedness. They sum up predicted bilateral shares across all possible partners thereby including imputed shares (out-of-sample) corresponding to zero and missing bilateral trade flows, to obtain, for each country, the share of trade to GDP predicted by its geography. In the second-step they employ the generated instrument to examine the relationship between trade and per capita income. They find that trade has a large and robust positive impact on per capita income.

The FR IV approach has gained widespread popularity in the literature on the growth effects of trade, migration and FDI (see, for analysis and discussion, (Rodriguez and Rodrik, 2001; Irwin and Terviö, 2002; Alcalá and Ciccone, 2004; Noguer and Siscart, 2005; Edmonds and Pavcnik, 2006; Harrison and Rodríguez-Clare, 2010; Feyrer, 2009; Andersen and Dalgaard, 2011; Ortega and Peri, 2014; Alesina et al., 2016; Pascali, 2017, among others).[1] However, the literature is often strikingly silent about the prediction method used to generate the instruments for trade in the per capita income regressions; particularly, whether out-of-sample bilateral trade flows are included in the instrument set for trade. Important exceptions are Noguer and Siscart (2005) and Gervais (2015), who argue that only in-sample predictions should be included in the instrument set because out-of-sample observations introduce noise and, therefore, reduce the strength of the instrument.

In this paper we show that the answer to the question 'does trade affect income' is highly sensitive to whether out-of-sample predictions are included in the instrument set. Our analysis and conclusions are related yet distinct from the issue of estimation method and whether to include the information contained in zero or missing observations of bilateral trade in the

[1] The FR IV approach has also been applied to the effects of trade on volatility that employ fitted measures of trade openness as an instrument for trade at the sector-level (e.g. (di Giovanni and Levchenko, 2009; Ardelean et al., 2017).

estimation of the trade equation used to predict bilateral trade. This is therefore not an extension of the work by Santos Silva and Tenreyro (2006) with respect to the FR-instrument. It is a demonstration that the selection of predictions after estimation of the bilateral trade equation, has effects on the results of trade's effect on income when using the predicted trade share as an instrument.[2]

Specifically, we generate bilateral trade shares predicted from randomly generated geographical characteristics to construct instruments for trade openness. These are then used to test whether trade causes growth in the second-stage regressions (Section 2 and 3). Excepting type I errors, randomly generated instruments should be weak and result in insignificant relationships between trade and income, regardless of whether any relationship exists. However, this is not what we find. The coefficients of trade openness are, on average, significantly positive in 96-100% of the counterfactual regressions when only in-sample predictions are used as instruments for trade openness in the second-stage regressions. This casts serious doubt on this IV procedure. Conversely, the coefficients of trade openness are, on average, insignificant in 99% of the simulations when out-of-sample predictions are included in the instrument variable (IV) set as we would expect in a randomized experiment.

Why does the exclusion of out-of-sample predictions in the IV set create spuriously positive relationships between income and trade? In Section 4 we show analytically that this result is driven by endogeneity of the instrument using in-sample only predictions. This instrument captures the number of distinct partners a country trades with, which, in turn, is directly affected by its income. Indeed, low-income countries have fewer trading partners than high-income countries because they face higher trading costs due to their institutions, infrastructure and business environment (Djankov et al., 2002). Thus, the coefficient of trade openness is upward biased when only in-sample bilateral trade flows are included in the instrument.

The paper proceeds as follows. The empirical strategy and estimates are presented in Sections 2 and 3. Section 4 shows analytically and empirically that the positive correlation between trade openness and the number of trade partners creates an upward bias in the coefficient of

[2]We recognize that the issue, in-sample vs out-of-sample, is of greater concern when estimating the trade equation using OLS, which is what we do here. The literature incorporates Santos Silva and Tenreyro (2006) findings by converting all missing observations of bilateral trade to zero prior to estimation using PPML. At first glance this seems to render the distinction in-sample vs. out-of-sample prediction moot. Nevertheless the findings in this paper remain relevant because they show that the unlinking of non-zero predictions from zero or missing values of actual bilateral trade is essential to the validity of the FR instrumentation strategy.

trade openness in the income regression. In Section 5 it is demonstrated that the precision of the original FR instrument increases by expanding the sample of countries used in the estimation of the bilateral trade and the income equations, or by using real trade openness and income data from the most recent version of the Penn World Tables (PWT v9.0) . Section 6 concludes.

3.2 Empirical Strategy

Consider the following income regression model:

$$\ln(Y_i) = \alpha_0 + \alpha_1 T_i + \alpha_2 \ln(N_i) + \alpha_3 \ln(A_i) + \boldsymbol{X_i'\alpha} + e_i \tag{3.1}$$

where Y_i is country i's income per capita; T_i is country i's total trade to GDP, i.e. trade openness; N_i and A_i is country i's population and area and is a proxy for within-country trade; and $\boldsymbol{X}$ is a vector of control variables. Identifying the effect of trade on income is complicated because of the two-way causal relationship between these two variables. FR address this issue by proposing a two-step procedure, which we follow as described below.

In the first-step FR generate instruments for trade openness by regressing bilateral trade openness on the following set of geographic characteristics:

$$\begin{aligned}\ln(\frac{\tau_{ij}}{GDP_i}) =& \beta_0 + \beta_1 \ln(D_{ij}) + \beta_2 \ln(N_i) + \beta_3 \ln(A_i) + \beta_4 \ln(N_j) \\ &+ \beta_5 \ln(A_j) + \beta_6 (L_i + L_j) + \beta_7 B_{ij} + \beta_8 B_{ij} \ln(D_{ij}) \\ &+ \beta_9 B_{ij} \ln(N_j) + \beta_{10} B_{ij} \ln(A_i) + \beta_{11} B_{ij} \ln(N_i) \\ &+ \beta_{12} B_{ij} \ln(A_j) + \beta_{13} B_{ij} (L_i + L_j) + \epsilon_{ij}\end{aligned} \tag{3.2}$$

where τ_{ji} is the total bilateral trade between country i and country j; D_{ij} is the geographic distance between country i and j; L is a dummy variable that takes on the value of 1 for landlocked countries and zero otherwise; B_{ij} is an indicator variable taking the value of 1 if countries i and j share a border and zero otherwise; and ϵ is a stochastic error term.

The estimates of Eq. (3.2) are used to form two instruments for country i's trade openness,

T_i:

$$\widehat{T}_i^{ISX} = \sum_{j \in \Omega_{ij}} e^{\ln(\widehat{\frac{\tau_{ij}}{GDP_i}})} \tag{3.3}$$

$$\widehat{T}_i^{TSX} = \sum_{j \in \Psi_{ij}} e^{\ln(\widehat{\frac{\tau_{ij}}{GDP_i}})} \tag{3.4}$$

where Ω_{ij} is the set of countries with which i actively trades; Ψ_{ij} is the set of all countries with which i can potentially trade (i.e., those with which it does and does not trade). In words, $\widehat{T}_i^{ISX}$ only includes in-sample predictions from Eq. (3.2), while $\widehat{T}_i^{TSX}$ includes predictions over the total sample of possible trade flows (in-sample plus out-of-sample predictions).

In the second-step we employ the generated instruments to investigate the relationship between trade and income using Two-Stage Least Squares (2SLS). Accordingly, we estimate the following first-stage regressions:

$$T_i = \gamma_0 + \gamma_1 \hat{T}_i^{ISX} + \gamma_2 \ln N_i + \gamma_3 \ln A_i + \boldsymbol{X'\gamma} + e_{1i} \tag{3.5}$$

$$T_i = \mu_0 + \mu_1 \hat{T}_i^{TSX} + \mu_2 \ln N_i + \mu_3 \ln A_i + \boldsymbol{X'\mu} + e_{2i} \tag{3.6}$$

where e is a stochastic error term. These regressions yield the instruments $\widehat{T}_i^{IS}$ (Eq. (3.5)) and $\widehat{T}_i^{TS}$ (Eq. (3.6)). We estimate the following second-stage income regressions:

$$\ln Y_i = a_0 + a_1 \hat{T}_i^{IS} + a_2 \ln N_i + a_3 \ln A_i + \boldsymbol{X'\xi} + e_{3i} \tag{3.7}$$

$$\ln Y_i = b_0 + b_1 \hat{T}_i^{TS} + b_2 \ln N_i + b_3 \ln A_i + \boldsymbol{X'\zeta} + e_{4i} \tag{3.8}$$

Using Eq. (3.8) without the X control variables as their baseline regression, FR find per capita income to be a significantly increasing function of trade openness. However, Rodriguez and Rodrik (2001), henceforth RR, show that the coefficient of trade openness becomes insignificant when geographic and institutional controls are added to the baseline regression. Thus, we include the geographic and institutional controls suggested by RR in the regressions below. The controls considered by Noguer and Siscart (2005) are included in the regressions in the Appendix 3C to ensure that our results are robust to this consideration.

The key question asked in this paper is whether we should include or exclude unobserved bilateral trade pairs from the instruments; i.e., whether we should use either $\widehat{T}_i^{ISX}$ or $\widehat{T}_i^{TSX}$ as instruments. Unobserved bilateral trade pairs are those that record zero or a missing value of bilateral trade. This is not a trivial issue because the maximum number of bilateral trading partners is significantly higher than the number of recorded trade flows and the results in most samples are influenced by this choice, as we show below. We would have a maximum number of bilateral trade flows of 15,778 in our 98-country sample if all countries traded with each other and every other possible partner, noting that there are 161 possible trading partners for each country. Instead, we observe 9,757 positive trade flows, which are used to estimate Eq. (3.2).[3] If the relationship between bilateral trade and geographic characteristics is very different for the non-trading or unobserved pairs, then more precise estimated trade effects can be achieved by excluding out-of-sample predictions from the instrument; a point originally made by Irwin and Terviö (2002). However, a much greater concern than efficiency is whether the coefficients of trade openness are biased in any of the income models given by Eqs. (3.7) and (3.8).

Our empirical strategy is as follows. First we estimate the first- and second-stage regressions using actual data to ensure that our results are consistent with those of FR and RR. Thereafter, we repeat the exercise using trade openness measures predicted from randomly generated geographic characteristics. In each round we estimate Eqs. (3.7) and (3.8) in which 1) controls, $\boldsymbol{X}$, are excluded; 2) distance to equator is included; 3) the percentage of land in the tropics in included; and 4) continental dummies are included. The last three specifications follow RR and have been widely used as controls in the literature. OLS and 2SLS/ IV regressions are presented in all cases.

3.3 Empirical Analysis

3.3.1 Data

Following FR we use bilateral trade flows in 1985 from the IMF Direction of Trade Statistics between the 98 countries in Mankiw et al. (1992)'s sample and 161 possible trading partners (98 - 1 = 97 partners within the sample and 64 countries in the rest of the world). These

[3]Helpman et al. (2008) Helpman et al. (2008) show a similar incidence of bilateral trade 'zeros' for each year between 1970 and 1997.

countries tend to have the most reliable data of the world's countries, be large, and have per capita income levels that are less likely to be determined by idiosyncratic factors. Population, income (real GDP per capita) and trade openness are from PWT Mark 5.6 . The CEPII GeoDist database is used as the source for the geographic variables: area, the landlocked dummy, latitudinal coordinates, bilateral distance (population-weighted) and dummy variables for common border. Data on the percentage of land or population in the tropics, and regional dummies (per continent) is from the Centre for International Development (CID) . In the robustness section we present results for a larger sample of countries and use higher quality data from the most recent version of PWT. More details on the data are provided in Appendix 3A.

3.3.2 FR and RR Replications

Table 3.1. Estimates of the Bilateral Trade Equation (Eq.(3.2)

	Variable	Border Interaction
Constant	-6.264***	6.687**
	(0.597)	(2.617)
$\ln Distance_{ij}$	-1.110***	0.286
	(0.034)	(0.338)
$\ln Population_i$	-0.134***	-0.284**
	(0.024)	(0.140)
$\ln Area_i$	-0.141***	0.052
	(0.017)	(0.144)
$\ln Population_j$	0.933***	-0.091
	(0.020)	(0.130)
$\ln Area_j$	-0.233***	-0.056
	(0.017)	(0.157)
Landlocked$_{ij}$	-0.671***	0.159
	(0.053)	(0.181)
Observations	9757	
R^2	0.318	

Note. The dependent variable is $\ln \tau_{ji}/GDP_i$. Column (1) reports the coefficient of the variable listed, and column (2) shows the coefficient of the interaction between the variable in the first column and border. Heteroscedasticity consistent standard errors are in parentheses. **, *** Significant at 5 and 1 percent, respectively.

Table 3.1 shows the estimates for the bilateral trade equation, Eq. (3.2). The coefficients of the geographic characteristics are almost all statistically significant, while the coefficients of the interaction terms are almost all insignificant, results that are in line with those of FR.

Turning to Table 3.2, which reports the income regression results for our main four model specifications each estimated by OLS, and 2SLS/IV using $\widehat{T}_i^{IS}$ and $\widehat{T}_i^{TS}$ as instruments for trade, respectively. The following conclusions emerge from the regressions: First, the null hypothesis of weak instruments is rejected in all cases, suggesting that $\widehat{T}_i^{IS}$ and $\widehat{T}_i^{TS}$ are both potentially good instruments. Second, the coefficients of trade openness in the second-stage regression are positive and statistically significant, regardless of whether $\widehat{T}_i^{IS}$ and $\widehat{T}_i^{TS}$ are used as instruments in the baseline FR regression (Model (1)) and when continental fixed effects are included in the regressions (Model (4)).

Consistent with the findings of RR, the coefficients of trade openness become insignificant in the IV-$\widehat{T}_i^{TS}$-regressions when the out-of-sample predictions are included in the instrument set and the share of the fraction of land within the tropics or distance to the equator are included as controls (Models (2) and (3)). However, when out-of-sample predictions are excluded from the IV-set (IV-$\widehat{T}_i^{IS}$-regressions), the coefficient of trade-openness becomes significant at least at the 5% level; a key result of Noguer and Siscart (2005). From these conflicting results it can be inferred that the coefficients of trade openness in the income equations must be biased in either the IV-$\widehat{T}_i^{IS}$-regressions or the IV-$\widehat{T}_i^{TS}$-regressions. Thus it can be concluded that the growth-trade nexus cannot be resolved before we know 1) which of the sampling procedures yield biased parameter estimates; and 2) the source of the bias. To identify which sampling procedure produces biased estimates we first generate both instruments for trade aggregating bilateral trade shares predicted from randomly generated geographical characteristics. Then we analyze the randomized instruments to identify the source of the bias, which we show is systematically related to per capita income.

3.3.3 Random Generated Instruments

In-sample and total-sample random generated trade openness, $\tilde{T}_i^{ISX}$ and $\tilde{T}_i^{TSX}$, respectively, are created for each Monte-Carlo replication $b = 1, \ldots, 1000$ by randomly drawing bilateral distances, areas and populations from normal distributions with means and standard deviations equal to those observed in the data. For each replication we ensure that geographic distances are symmetric across bilateral trading partners, $D_{ij}(b) = D_{ji}(b)$, and that country i's area and

Table 3.2. Estimates of the Income Equation using Actual Data

	Model (1)			**Model (2)**		
	OLS	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	OLS	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$
Real openness	0.911***	2.454***	2.743***	0.578***	0.463	0.702**
	(0.306)	(0.686)	(0.736)	(0.204)	(0.377)	(0.339)
$\ln Population_i$	0.271***	0.381***	0.402***	0.106	0.097	0.116
	(0.102)	(0.131)	(0.140)	(0.072)	(0.074)	(0.073)
$\ln Area_i$	-0.087	0.084	0.116	-0.087	-0.100	-0.074
	(0.088)	(0.129)	(0.131)	(0.065)	(0.074)	(0.073)
Distance to equator$_i$				4.158***	4.190***	4.124***
				(0.326)	(0.332)	(0.325)
Obs.	98	98	98	98	98	98
R^2	0.145	-	-	0.600	-	-
First-stage regressions:						
$\widehat{T}_i$	-	6.818***	7.166***	-	7.606***	8.484***
	-	(1.356)	(1.427)	-	(1.931)	(2.095)
Partial R^2	-	0.284	0.321	-	0.282	0.335
KP *rk* Wald F-stat	-	25.27	25.20	-	15.51	16.40
	Model (3)			**Model (4)**		
	OLS	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	OLS	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$
Real openness	0.636***	0.643	1.083***	0.704***	1.073**	1.217***
	(0.205)	(0.416)	(0.382)	(0.254)	(0.507)	(0.442)
$\ln Population_i$	0.072	0.073	0.109	-0.037	0.018	0.040
	(0.076)	(0.077)	(0.078)	(0.104)	(0.109)	(0.103)
$\ln Area_i$	-0.082	-0.081	-0.033	0.040	0.065	0.074
	(0.070)	(0.082)	(0.082)	(0.065)	(0.076)	(0.073)
% Land in tropics$_i$	-1.580***	-1.579***	-1.536***			
	(0.167)	(0.169)	(0.167)			
Sub-Saharan Africa$_i$				-1.889***	-1.830***	-1.806***
				(0.206)	(0.210)	(0.206)
Latin America				-0.581**	-0.472*	-0.430*
				(0.221)	(0.250)	(0.233)
East Asia				-0.626*	-0.776**	-0.834**
				(0.340)	(0.367)	(0.348)
Obs.	98	98	98	98	98	98
R^2	0.547	-	-	0.594	-	-
First-stage regressions:						
$\widehat{T}_i$	-	7.673***	8.128***	-	6.745***	7.843***
	-	(1.729)	(1.861)	-	(1.435)	(1.588)
Partial R^2	-	0.289	0.331	-	0.230	0.305
KP *rk* Wald F-stat	-	19.70	19.09	-	22.08	24.39

Note. Heteroscedastic consistent standard errors are in parentheses. The standard errors in the IV-regressions are corrected for the errors created from the generated regressors. $\widehat{T}_i^{IS}$ is the predicted trade openness based on in-sample observations only. $\widehat{T}_i^{TS}$ is the predicted trade openness based on the total sample, i.e., including out-of-sample predictions. The KP *rk* Wald F-stat is the Kleibergen-Paap *rk* Wald F-statistic. Exogenous variables are included in the first-stage regressions but not shown. *,**, *** Significant at 10, 5 and 1 percent, respectively.

Table 3.3. Estimates of the Income Equation using Randomized Instruments (1000 replications)

Second-stage results:	Model (1)		Model (2)		Model (3)		Model (4)	
	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$
Trade share$_i$	-4.000	6.691	2.266	3.632	0.531	4.289	-1.938	6.062
	(88.754)	(0.892)	(89.180)	(0.676)	(62.945)	(0.715)	(66.014)	(1.297)
	[9]	[1000]	[7]	[997]	[11]	[1000]	[8]	[983]
	{1}	{1000}	{2}	{989}	{3}	{997}	{3}	{960}
Observations	98	98	98	98	98	98	98	98
First-stage regression (selected results):								
$\tilde{T}_i$	7.463	25.675	6.542	30.105	6.748	28.462	6.262	20.696
	(25.862)	(4.235)	(25.659)	(6.385)	(25.729)	(5.608)	(24.294)	(4.616)
	[136]	[1000]	[114]	[998]	[116]	[1000]	[125]	[980]
	{72}	{1000}	{63}	{979}	{64}	{996}	{67}	{951}
Partial R^2	0.013	0.125	0.013	0.112	0.013	0.114	0.013	0.074
	(0.019)	(0.029)	(0.019)	(0.033)	(0.019)	(0.032)	(0.019)	(0.026)
KP *rk* Wald *F-stat*	1.196	18.489	1.147	9.462	1.166	13.080	1.217	11.547
	< 4 >	< 955 >	< 5 >	< 434 >	< 5 >	< 798 >	< 5 >	< 630 >

Notes. The table reports average values from 1000 replications. The standard deviation of this average is reported in parentheses. For the estimated coefficients, the number of replications that produce an estimate significant at least at the 10% level is in [square brackets] and the number of replications in which the estimate is significant at least at the 5% level is in curly brackets. The number of times the KP *rk* Wald *F*-stat is greater than 10 is in <angle brackets>. Model (1) controls for area and population (in logs). Models (2), (3) and (4) add distance to the equator, percentage of land in the tropics and continental dummies, respectively, as control variables. Exogenous variables are included in the first-stage regressions but not shown. Full results for the second-stage regressions are reported in Appendix Table B1.

population do not change whether i is the origin or the destination country, i.e., $A_i(b) = A_{j=i}(b)$ and $N_i(b) = N_{j=i}(b)$. The landlocked status is drawn from a random variable where the probability of drawing 1 (e.g. landlocked) is equal to the observed frequency of landlocked countries in the data. For each replication we ensure that country i's landlocked status does not change, regardless of whether i is the origin or the destination country, i.e., $L_i(b) = Lj = i(b)$. Finally, we draw symmetric borders from a random variable where the probability of drawing 1 equals the observed incidence of a border in the data.

First- and second-stage regressions are estimated for each replication. Table 3.3 summarizes the income regression results when the instruments are randomly generated (1000 replications for each model). The table reports 1) the average coefficients and the corresponding standard deviation (in parentheses); 2) the number of replications for which the coefficients of trade openness in the income regressions are statistically significant at the 10% [in square brackets] and 5% in curly brackets levels; 3) the number of Kleibergen-Paap *rk* Wald weak identification tests for which the F-statistic in the first-stage regression is greater than 10 <in angle brackets>.

The results are remarkably sensitive to whether out-of-sample predictions are included in the IV set. Considering the results from the first-stage regressions, when only in-sample predictions are included in the regressions, IV-$\tilde{T}_i^{IS}$, the instruments turn out, in most cases, to be potentially strong. The KP *rk* Wald F-stats are larger than 10 in 43-95% of the cases and range, on average, between 9.5 and 18.5. Furthermore, the simulated coefficients of trade are statistically significant at the 5% level in at least 98% of the replications in the income regressions.

The results are quite different when the $\tilde{T}_i^{TS}$ instrument is used. In only 1% of the cases, at most, the coefficient of trade openness is significant at conventional significance levels. This suggests that the coefficients of trade openness are unbiased when $\tilde{T}_i^{TS}$ is used as an instrument for trade openness and, therefore, that causality is not found where it does not exist. Similarly, the F-tests of excluded restrictions are, on average, extremely low and the KP *rk* Wald F-statistic is, on average, very low and is greater than 10 only in 0.5% of the simulations. Again this suggests that trade openness is independent of geographic characteristics when these are randomly generated, as expected.

Overall, the simulations show that research relying on in-sample predictions will, almost surely, find a positive relationship between trade and income even if such a relationship does not exist; a relationship that disappears when out-of-sample predictions are included in the instrument set. This implies that the estimated effect of trade is biased when out-of-sample observations are excluded from the instrument set because of feedback effects from income to trade openness – a result we prove analytically in the next section.

3.4 The nexus between per capita income and number of trade partners

So what is giving these seemingly paradoxical results in the previous section? To answer this question we need to focus on the first-step, in which the instruments are generated.

When geographic characteristics are randomly generated, the bilateral trade equation (Eq. (3.2) approximately predicts the logs of the average bilateral trade openness. More formally,

$$\ln\left(\frac{\widehat{\tau_{ij}(b)}}{GDP_i}\right) \approx \overline{\ln(\frac{\tau_{ij}}{GDP_i})} = k,$$

where k is a constant equal to the average trade openness. Substituting this expression into

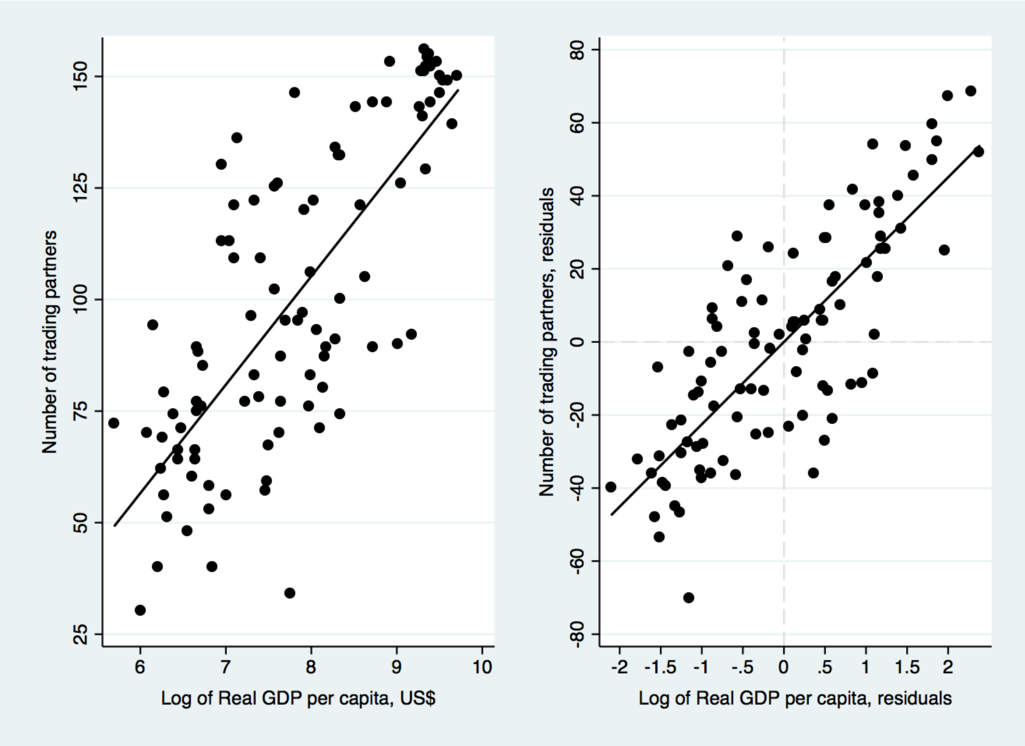

Figure 3.1. The relationship between the number of trading partners and per capita income. The left-hand-side panel plots the actual observations while the right-hand-side panel plots the residuals for each variable after accounting for the logs of population and area.

Eqs. (3.3) and (3.4), yields the following two distinctive instruments:

$$\tilde{T}_i^{ISX}(b) = \sum_{j \in \Omega_{ij}} e^{\ln\left(\frac{\widehat{\tau_{ij}(b)}}{GDP_i}\right)} \approx \sum_{j \in \Omega_{ij}} e^k = NP_i e^k,$$

$$\tilde{T}_i^{TSX}(b) = \sum_{j \in \Psi_{ij}} e^{\ln\left(\frac{\widehat{\tau_{ij}(b)}}{GDP_i}\right)} \approx \sum_{j \in \Psi_{ij}} e^k = 161 e^k,$$

where NP_i is the number of countries with which country i trades actively, and 161 is the maximum number of potential trade partners country i can trade with in our data. In other words, in each replication, $\tilde{T}i^{ISX}(b)$ captures the number of effective trade partners, which vary from country to country. However, when out-of-sample predictions are included in the data, $\tilde{T}_i^{TSX}(b)$ captures stochastic values that are scattered around $161e^k$ for all countries; where $161e^k$ is close to the values recovered from the estimates in this paper.[4]

[4]In our data, the average log of the bilateral trade share is -8.922, which implies a value for e^k of 0.0013. With an average of 99.56 partners, the approximated average values for $\tilde{T}_i^{ISX}$ and $\tilde{T}_i^{TSX}$ are 0.0133 and 0.0214, respectively. These numbers are close to the average values for $\tilde{T}_i^{ISX}$ and $\tilde{T}_i^{TSX}$ of 0.0157 and 0.0231 across all countries and the replications in this paper.

What is the implication of these considerations for the 2SLS results? The estimated coefficient of $\tilde{T}_i^{IS}$ in the first-stage regression, γ_1, in Eq. (3.5), tends to be significantly positive because a country's trade openness and number of trading partners are positively correlated. At the same time, income per capita and the number of trading partners are positively correlated, as shown in Figure 3.1 (the correlation coefficient is 0.77 in the left-hand side panel).[5] The nexus between per capita income and the number of trading partners becomes even tighter when land area and population are controlled for, as shown in the right panel of Figure 3.1.

Intuitively, since the second-stage estimated coefficient of income can be derived as the ratio of the coefficients of the instruments from the reduced form and the first-stage regressions, the positive correlation between income per capita and the number of trading partners implies that the estimated coefficient of trade openness, a_1, in the second-stage Eq. (3.7), tends to be positive and significant too. If, by contrast, the out-of-sample observations, are included in the instrument set, $\tilde{T}_i^{TSX}$ does not have any identifying variation, the significance of the estimated μ_1 in the first-stage regressions, Eq. (3.6), and that of the estimated trade effect b_2 in the second-stage, Eq. (3.8), tends towards zero. This is exactly what the results in Table 3.3 show.

To show more explicitly that the coefficients of trade openness in the income regressions are mostly driven by the number of trade partners when the out-of-sample observations are excluded from the data, the variation in $\tilde{T}_i^{ISX}$ is decomposed into trade openness (intensive margin) and the number of countries that country i trades with, NP_i (extensive margin):

$$\widehat{T}_i^{ISX} = \sum_{j\in\Omega_{ij}} e^{\ln\left(\frac{\widehat{\tau_{ij}(b)}}{GDP_i}\right)} = NP_i \frac{\sum_{j\in\Omega_{ij}} e^{\ln\left(\frac{\widehat{\tau_{ij}(b)}}{GDP_i}\right)}}{NP_i} = NP_i \frac{\widehat{T}_i^{ISX}}{NP_i} = NP_i \overline{\widehat{T}_i^{ISX}}$$

where $\overline{T_i^{ISX}}$ - is each country's average predicted bilateral trade openness.

The results of decomposing each margin into separate instruments for trade openness are presented in Table 3.4, where actual data are used. The regressions reveal a very distinct pattern. When NP_i is used as the only instrument for trade, the estimated coefficients of trade in the income regressions are very close in magnitude to the average coefficients obtained from

[5]Poor countries such as Botswana, Burkina Faso, Chad and Nepal, for example, have at most 40 trading partners, while advanced countries, such as Australia and the US, have at least 150 partners. Even small advanced economies such as Denmark, have a large number of trading partners (153), suggesting that the positive relationship is not driven by the size of the population or land area.

the instruments when randomized, $\tilde{T}_i^{ISX}$ (see Table 3.3). This result confirms our hypothesis that the identifying variation in $\tilde{T}_i^{ISX}$ is driven solely by the number of trade partners of country i.

Turning to the second-stage results in Table 3.4, the estimated trade effect is large and significant only when the number of trading partners, for each individual country, NP_i, is included as an instrument for trade. This implies that NP_i and $\overline{\widehat{T}_i^{ISX}}$ identify different vectors of parameters – a result that is not revealed by tests of overidentifying restrictions (Parente and Santos Silva, 2012). In addition, comparing the results in the first two columns for each model panel of Table 3.4, the estimated trade effects are not statistically different[6]; however, NP_i by itself is the strongest of the two instruments for trade (the corresponding KP statistics are greater than 10 for all models). Finally, note that the null hypotheses of overidentifying restrictions are rejected at the 1% level in all cases, underscoring that the validity of the overidentifying restrictions are not sufficient conditions for the model to be identified.

These findings suggest that the cross-country variation in NP_i is what makes the coefficient of $\widehat{T}_i^{ISX}$ more significant than that of $\widehat{T}_i^{TSX}$ in the income regressions (see results in Table 3.2, and Appendix Tables C1 and C2). However, it is the same variation that makes $\widehat{T}_i^{ISX}$ an invalid instrument for trade because the number of trading partners is endogenous to income, i.e., the Cov$(\widehat{T}^{ISX}, e_3) \neq 0$; a violation of the exclusion restriction. Indeed, more developed countries have access to better institutions, infrastructure and business environments (Djankov et al., 2002) so that the cost of engaging in trade (exporting and importing) tends to be lower for them than for poor countries allowing them to trade with more partners.

The model by Helpman et al. (2008) offers a simple framework that addresses this issue. Extending the model of Melitz (2003) to include fixed costs of exporting and bounded productivity distributions, they show that some countries do not trade with each other because the firms are not sufficiently productive to penetrate each other's markets. In this framework destinations with lower fixed cost of exporting are, ceteris paribus, more likely to trade with any other country. Along the same vein using product level export data, Baldwin and Harrigan (2011) show that richer countries are more likely than poor countries to import from the US.

[6] The values for the t-statistics are: -0.9825; 1.1504; -1.3464; -1.6978. Thus, none of the differences are significant at the 5% level; however, the last restriction is marginally rejected at the 10% level.

Table 3.4. 2SLS Estimates of the Income Equation Using Actual Data in the Extensive and Intensive Margins of $\widehat{T}^{ISX}$

Second-stage results:	**Model (1)**			**Model (2)**		
Trade share$_i$	4.902***	6.762***	-0.778	2.236***	3.616***	-1.814
	(1.223)	(1.445)	(1.839)	(0.673)	(0.993)	(1.955)
ln $Population_i$	0.555***	0.688***	0.151	0.240**	0.351**	-0.086
	(0.206)	(0.261)	(0.173)	(0.114)	(0.175)	(0.212)
ln $Area_i$	0.355	0.561*	-0.274	0.093	0.242*	-0.346*
	(0.233)	(0.331)	(0.222)	(0.103)	(0.133)	(0.208)
Distance to equator$_i$				3.700***	3.318***	4.820***
				(0.487)	(0.792)	(0.856)
Obs.	98	98	98	98	98	98
First-stage regressions:						
NP_i	0.004***	0.004***		0.006***	0.005***	
	(0.001)	(0.001)		(0.002)	(0.002)	
$\overline{T_i^{ISX}}$	385.26**		320.12*	442.69**		303.03*
	(145.67)		(177.66)	(170.57)		(177.84)
Partial R^2	0.197	0.139	0.04	0.212	0.136	0.037
KP *rk* Wald F-stat	12.71	23.00	3.25	5.765	10.97	2.903
Hansen J-statistic	7.28			10.86		
Second-stage results:	**Model (3)**			**Model (4)**		
Trade share$_i$	2.622***	4.336***	-2.493	3.116***	6.256***	-4.272
	(0.763)	(1.019)	(2.603)	(0.948)	(1.588)	(4.632)
ln $Population_i$	0.236*	0.377**	-0.185	0.324**	0.795***	-0.783
	(0.125)	(0.192)	(0.277)	(0.164)	(0.289)	(0.723)
ln $Area_i$	0.134	0.320*	-0.422	0.202*	0.412*	-0.294
	(0.123)	(0.175)	(0.278)	(0.115)	(0.223)	(0.309)
% Land in tropics$_i$	-1.384***	-1.215***	-1.888***			
	(0.212)	(0.308)	(0.359)			
Sub-Saharan Africa$_i$				-1.502***	-0.998**	-2.687***
				(0.272)	(0.424)	(0.713)
East Asia$_i$				0.129	1.053*	-2.045
				(0.331)	(0.604)	(1.340)
Latin America$_i$				-1.606***	-2.882**	1.396
				(0.544)	(1.132)	(1.973)
Obs.	98	98	98	98	98	98
First-stage regressions:						
NP_i	0.006***	0.005***		0.005***	0.003***	
	(0.001)	(0.001)		(0.001)	(0.001)	
$\overline{T_i^{ISX}}$	446.14**		297.042	444.18**		228.22
	(170.280)		(181.120)	(168.680)		(173.360)
Partial R^2	0.208	0.133	0.035	0.156	0.078	0.024
KP *rk* Wald F-stat	7.81	16.05	2.69	9.05	15.4	1.733
Hansen J-statistic	11.743			12.736		
p-value	[0.001]			[0.000]		

Note. Heteroscedastic consistent standard errors are in parentheses. The standard errors in the second-stage are corrected for the errors created from the generated regressors. $\widehat{T}_i^{IS}$ is the predicted trade openness based on in-sample observations only. NP_i and $\widehat{T}i^{ISX}$ are i's number of trading partners and average bilateral predicted trade openness, respectively. The KP *rk* Wald F-stat is the Kleibergen-Paap *rk* Wald F-statistic. Exogenous variables are included in the first-stage regressions but not shown. *, **, *** Significant at 10, 5 and 1 percent, respectively.

Table 3.5. Estimates of the Income Equation using Actual Data: Larger Sample of Countries

Second-stage results:	**Model (1)**	**Model (2)**	**Model (3)**	**Model (4)**
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$
Trade share$_i$	3.058***	1.157**	1.097*	1.736***
	(0.796)	(0.566)	(0.635)	(0.541)
$\ln Population_i$	0.330***	0.084	0.064	0.156*
	(0.117)	(0.064)	(0.078)	(0.084)
$\ln Area_i$	0.126	0.001	0.005	0.092
	(0.120)	(0.068)	(0.072)	(0.065)
Distance to equator$_i$		3.601***		
		(0.346)		
% Land in tropic$_i$			-1.335***	
			(0.195)	
Sub-Saharan Africa$_i$				-1.544***
				(0.167)
East Asia$_i$				-0.311
				(0.190)
Latin America$_i$				-0.990***
				(0.357)
Obs.	147	147	146	147
First-stage regressions:				
$\widehat{T}_i$	3.346***	3.357***	3.352***	3.317***
	(0.604)	(0.774)	(0.824)	(0.656)
Partial R^2	0.169	0.145	0.139	0.151
	30.706	18.789	16.566	25.565

Note. The dependent variable is log of real GDP per capita reported by PWT Mark 5.6 for the year 1985. Heteroscedastic consistent standard errors are in parentheses. The standard errors in income regressions are corrected for the errors created from the generated regressors. $\widehat{T}_i^{TS}$ is the predicted trade openness based on the total sample; i.e. including out-of-sample predictions. The KP *rk* Wald *F*-stat is the Kleibergen-Paap *rk* Wald *F*-statistic. Exogenous variables are included in the first-stage regressions but not shown. *, **, *** Significant at 10, 5 and 1 percent, respectively.

3.5 Does trade really matter for growth?

Our findings imply that even though the FR baseline regressions yield unbiased results, their efficiency and consistency properties may be compromised by the small country sample and data quality. In this section we show that the precision of the original FR instrument improves when we use a larger sample of countries, real trade openness as opposed to nominal trade openness, and improved quality of GDP data provided in the latest version of PWT v9.0.

3.5.1 Using a larger country sample

Table 3.5 reports the first- and second-stage estimates of the income equation when the sample of countries is increased (from 98) to 146/147 and $\widehat{T}_i^{TS}$ is used as instrument for trade. The data are for trade openness and real GDP are identical to that used earlier, from PWT Mark 5.6. The coefficient of trade openness is significantly positive in all models; even when the fraction of land in the tropics or the distance to the equator are included as controls. Furthermore, in Appendix Table D1, when the sample of countries is expanded (from 98 to 104-146, where the number of observations are limited by the availability of controls), it is shown that the statistical significance of the coefficient of $\widehat{T}_i^{TS}$ improves, relative to the results in Table C1, in 8 out of the 10 additional specifications in which additional controls are included in the regressions. Thus, the increased number of countries in our sample yields significant trade effects in 12 of the 14 estimated models, which is a considerable improvement over the regression results in Table C1.

When the instruments are randomly generated, Appendix Table D2 shows that the results in Section 3.3 are robust to the larger sample of countries. Again, the randomly generated instrument using only in-sample predictions, $\tilde{T}_i^{IS}$, consistently generates positive and significant income-effects of trade openness, while its counterpart, $\tilde{T}_i^{TS}$, which includes out-of-sample predictions, only produces significant income-effects in 1%, or less, of the replications. These results reinforce the results in the previous sections that $\widehat{T}_i^{TS}$ yields unbiased estimates of the income effects of trade.

3.5.2 Using real openness and improved data

Trade openness has thus far been measured as nominal imports plus exports divided by nominal GDP. However, Alcalá and Ciccone (2004) point out that real openness (nominal imports plus exports divided by purchasing power parity (PPP) GDP) is the appropriate openness variable to use because it eliminates distortions in nominal openness induced by cross-country differences in relative prices of non-tradable products. Supposing that specialization increases productivity in the tradable sector more than it does in the non-tradable sector, then the relative price of non-tradable goods increases due to the Balassa-Samuelson effect. However, as non-tradable goods enter the calculation of GDP, nominal trade openness might not necessarily increase even though the increased specialization should have been echoed in an increasing trade openness. Alcalá and Ciccone (2004) argue that a monotonic relationship between specialization and openness is restored if one expresses trade as a percentage of PPP GDP instead of GDP. In the absence of data for real trade in PPP, Alcalá and Ciccone (2004) measure real openness as exports plus imports in US$ relative to GDP in US$ PPP. However, this measure mixes up nominal and real values in the numerator and denominator and is sensitive to the level of the exchange rate in the time at which real openness is measured.

Real openness is used as the independent variable in the regressions in Table 3.6, where real openness is based on the most recent PWT v9.0 , which not only provides new data on real trade in PPP, but also improved income data (see, for an in-depth analysis, Feenstra et al. (2009) and Feenstra et al. (2015)). The measure of income per capita we take from PWT v9.0 is the real $\mathrm{GDP^E}$ per capita. This measure is closest to the one available in previous versions of the PWT, including the PWT Mark5.6 used by FR, and it does not account for differences in the price of exports and imports. Data for 1985 are used in all regressions for comparability purposes, even if 2014 data are available. The 1985-data are probably of better quality as data are often adjusted several years after they are first published.

Even though 33 years have passed since 1985, the per capita GDP data used by FR PWT Mark5.6 for 1985 has been improved in the PWT v9.0 in terms of retrospective adjustments made by national statistical agencies and PPP conversions. The second-stage regressions using per capita GDP from PWT Mark5.6 (data used by FR) and real $\mathrm{GDP^E}$ per capita in 1985 from PWT v9.0 as dependent variables are presented in Table 3.6. The coefficients of real openness are statistically significant in seven of the eight regressions, which is an improvement over the results in Table 3.2, where (nominal) openness is significantly positive in only two of the four cases. In Appendix Table D3 we show that the significance of the coefficient of $\widehat{T}_i^{TS}$ improves in 7 out of the 10 additional specifications relative to the regressions using the FR data in Table C1, when both real openness and more recent income data are used; thus strengthening the conclusion of FR that per capita income is positively related to trade. Finally, as shown in the Appendix Table D4, the results from random generated instruments in Section 3.3.3 are robust to the use of real openness and new measures of GDP per capita, $\mathrm{GDP^E}$.

Table 3.6. Estimates of the Income Equation using Real Openness

Second-stage results:	**Model (1)**		**Model (2)**	
	GDP v5.6	GDP$^{\mathrm{E}}$	GDP v5.6	GDP$^{\mathrm{E}}$
Trade share$_i$	2.270***	2.364***	0.585	0.830*
	(0.492)	(0.505)	(0.398)	(0.434)
ln $Population_i$	0.251**	0.218*	0.089	0.071
	(0.102)	(0.113)	(0.070)	(0.084)
ln $Area_i$	0.087	0.144	-0.085	-0.013
	(0.103)	(0.104)	(0.075)	(0.079)
Distance to equator$_i$			3.945***	3.592***
			(0.396)	(0.402)
Obs.	96	96	96	96
First-stage regressions:				
$\widehat{T}_i$	8.075***	8.075***	7.463***	7.463***
	(1.439)	(1.439)	(2.161)	(2.161)
Partial R^2	0.335	0.335	0.255	0.255
KP rk Wald F-stat	31.478	31.478	11.922	11.922
Second-stage results:	**Model (3)**		**Model (4)**	
	GDP v5.6	GDP$^{\mathrm{E}}$	GDP v5.6	GDP$^{\mathrm{E}}$
Trade share$_i$	0.753*	0.998**	0.919**	1.223**
	(0.413)	(0.452)	(0.430)	(0.506)
ln $Population_i$	0.055	0.042	-0.073	-0.049
	(0.072)	(0.084)	(0.093)	(0.115)
ln $Area_i$	-0.064	0.007	0.078	0.131*
	(0.080)	(0.085)	(0.068)	(0.077)
% Land in tropics$_i$	-1.486***	-1.339***	0	0
	(0.179)	(0.192)	(0.000)	(0.000)
Sub-Saharan Africa$_i$			-1.777***	-1.503***
			(0.216)	(0.261)
East Asia$_i$			-0.538**	-0.463*
			(0.225)	(0.262)
Latin America$_i$			-0.451	-0.453
			(0.318)	(0.351)
Obs.	96	96	96	96
First-stage regressions:				
$\widehat{T}_i$	8.020***	8.020***	7.480***	7.480***
	(1.860)	(1.860)	(1.681)	(1.681)
Partial R^2	0.285	0.285	0.237	0.237
KP rk Wald F-stat	18.586	18.586	19.796	19.796

Note. The country sample is the 98 sample excluding Papua New Guinea and Somalia, for which data are not available in PWT v9.0. $\widehat{T}_i$ is the predicted trade openness based on the total sample; i.e. including out-of-sample predictions. GDP v5.6 refers to the measure of real GDP per capita reported by the PWT Mark 5.6, while GDPE refers to the measure constructed using the expenditure-side GDP at current PPPs reported in PWT v9.0. Real trade openness is from PWT v9.0. Heteroscedastic consistent standard errors are in parentheses. The standard errors in income regressions are corrected for the errors created from the generated regressors. The KP rk Wald F-stat is the Kleibergen-Paap rk Wald F-statistic. Exogenous variables are included in the first-stage regressions but not shown. *, **, *** Significant at 10, 5 and 1 percent, respectively.

3.5.3 Economic significance

Thus far we have not discussed the magnitude of the coefficient of trade openness. This subsection discusses trade openness' contribution to per capita income and its economic significance relative to other determinants of income.

The average coefficient estimates of trade openness for Models 2-4, using only the IV-$\tilde{T}_i^{TS}$ regression results, is 0.73 (Table 3.2) when nominal trade openness is used, while it is 0.91 when real openness is used (Table 3.6). The size of the coefficients indicates that trade has been influential for the income growth over the past last globalization wave, 1960-2009, in the OECD countries. Using the updated data for 21 OECD countries of Madsen (2009), the nominal trade openness increased by approximately 10 percentage points as a simple average over the period 1960-2009; thus contributing to a 9.1% increase in real per capita income when the real openness elasticities are used. Conversely, the approximate 12 percentage point trade collapse over the period 1913-1932 resulted in an income contraction of 10.9% compared to what it would have been had trade openness stayed at the 1913 level. Thus, while these counterfactual simulations show that trade is influential for growth, the effects are comparatively small relative to technological progress, noting that growth is driven by technological progress in steady state. An important qualification here is that technological progress itself is influenced by trade openness. The latter's effect on technological progress is lagged because the absorption of the 'new' knowledge associated with trade depends on human capital. In this setting we can distinguish trade's contemporaneous effect on income from the effect of technological progress on income.[7]

In sum, per capita income grew 209% over the period 1960-2009, on average, in the OECD countries (Madsen, 2009), suggesting that the 9.1% trade-induced growth has not made a comparatively large contribution when factoring in that the trade expansion in the period 1960-2009 was probably the largest 50-year expansion in the OECD countries' history.

[7]We do recognize that a more comprehensive analysis that identifies the mechanisms through which trade affects income would involve estimation of a structural model. This, however, is beyond the scope of this paper.

3.6 Concluding remarks

Following the influential paper of FR the causal effects of trade openness on per capita income has not yet been resolved. In this paper we show that the diverging results, to a large degree, are driven by the choice of a seemingly innocent sampling procedure – so innocent that most papers do not even mention it. This paper shows that the statistical significance of trade openness in income regressions is highly sensitive to whether out-of-sample bilateral trade share predictions are included in the IV-set, because the instrument for trade openness is endogenous to income when out-of-sample predictions are omitted from the IV-set.

Using bilateral trade shares predicted from randomly generated geographical characteristics to form instruments for trade openness, we show that a significantly positive relationship between income and trade is spuriously created when only in-sample bilateral trade flows are included in the instrument set. However, the significance of randomly created trade openness disappears once the out-of-sample predictions are included in the IV-set, suggesting that the estimates can only be unbiased if out-of-sample predictions are included in the IV-set.

Why is an apparently innocent truncation of the IV-set so influential for the significance of trade openness in the income equation? The answer lies in the fact that the truncation of the IV-set to include in-sample bilateral trade only causes the instrument to capture each country's number of trading partners. We show analytically and empirically that a significantly positive relationship between income and the instrument for trade is spuriously created because high-income countries have more trade partners than low-income countries. However, inclusion of out-of-sample predictions in the sample eliminates this endogeneity bias. From this it can be concluded that the results of RR, in which out-of-sample observations are included in the regressions, still stands.

Is this finding a setback for FR's finding of positive growth effects of trade? Based on the 98-sample regressions of RR it would seem so. However, we find positive income-effects of trade when the country sample is expanded and when real openness and income data from the most recent PWT are used - even when various controls are included in the regressions. The coefficients of trade openness are significantly positive in 12 out of 14 model specifications in which various controls are included, when the country sample is expanded, and in 11 out of 14 cases when openness is measured in real terms, even when the number of countries is limited to 98. As a precaution, it has to be noted that the statistical significance of openness in the income equation is generally not high, suggesting that the openness-income nexus is still not sufficiently strong to make firm conclusions about the causal effects of trade on income. Furthermore, counterfactual simulations suggest that the last globalization wave, over the period 1960-2009, contributed only a 9.1% increase in per capita income in the OECD countries, which is less than 5% of the 209% increase for the average OECD countries over this period. Thus, while trade is likely to enhance productivity, its contribution to growth is small relative to that of technological progress.

Our results have wide-spread implications for empirical trade modelling. An implication of our analysis is in that out-of-sample predictions from the bilateral trade equation should always be included in the instrument set for trade openness in regressions in which outcome variables are positively related to the number of trade partners, such as per capita income, investment, saving, education, R&D-intensity, etc. The same result applies to cross-border flows based on the FR framework, such as foreign direct investment, migration, foreign patenting, and portfolio investment, because the number of bilateral flows for these variables is also likely to be endogenous to income.

References

Alcalá, F. and Ciccone, A. (2004). Trade and Productivity, *Quarterly Journal of Economics* **119**(2): 613–646.

Alesina, A., Harnoss, J. and Rapoport, H. (2016). Birthplace diversity and economic prosperity, *Journal of Economic Growth* **21**(2): 101–138.

Andersen, T. B. and Dalgaard, C.-J. (2011). Flows of people, flows of ideas, and the inequality of nations, *Journal of Economic Growth* **16**(1): 1–32.

Ardelean, A., León-Ledesma, M. and Puzzello, L. (2017). Industry Volatility and International Trade, *Working Paper 1709*, School of Economics, University of Kent.

Baldwin, R. and Harrigan, J. (2011). Zeros, Quality, and Space: Trade Theory and Trade Evidence, *American Economic Journal: Microeconomics* **3**(2): 60–88.

di Giovanni, J. and Levchenko, A. A. (2009). Trade Openness and Volatility, *Review of Economics and Statistics* **91**(3): 558–585.

Djankov, S., La Porta, R., Lopez-De-Silanes, F. and Shleifer, A. (2002). The Regulation of Entry, *Quarterly Journal of Economics* **117**(1): 1–37.

Edmonds, E. V. and Pavcnik, N. (2006). International trade and child labor: Cross-country evidence, *Journal of International Economics* **68**(1): 115–140.

Feenstra, R. C., Heston, A., Timmer, M. P. and Deng, H. (2009). Estimating Real Production and Expenditures Across Nations: A Proposal For Improving The Penn World Tables, *The Review of Economics and Statistics* **91**(1): 201–212.

Feenstra, R. C., Inklaar, R. and Timmer, M. P. (2015). The Next Generation of the Penn World Table†, *American Economic Review* **105**(10): 3150–3182.

Feyrer, J. (2009). Trade and Income – Exploiting Time Series in Geography, *Working Paper 14910*, National Bureau of Economic Research.

Frankel, J. A. and Romer, D. (1999). Does Trade Cause Growth?, *American Economic Review* **89**(3): 379–399.

Gallup, J. L., Sachs, J. D. and Mellinger, A. D. (1999). Geography and Economic Development, *International Regional Science Review* **22**(2): 179–232.

Gervais, A. (2015). Trade and growth: A gravity approach, *Southern Economic Journal* **82**(2): 453–470.

Harrison, A. and Rodríguez-Clare, A. (2010). Trade, Foreign Investment, and Industrial Policy for Developing Countries, *in* D. Rodrik and M. Rosenzweig (eds), *Handbook of Development Economics*, Vol. 5, Elsevier, pp. 4039–4214.

Helpman, E., Melitz, M. and Rubinstein, Y. (2008). Estimating Trade Flows: Trading Partners and Trading Volumes, *The Quarterly Journal of Economics* **123**(2): 441–487.

Heston, A. and Summers, R. (1991). The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988, *Quarterly Journal of Economics* **106**(2): 327–368.

International Monetary Fund (n.d.). Direction of Trade Statistics.

Irwin, D. A. and Terviö, M. (2002). Does trade raise income?: Evidence from the twentieth century, *Journal of International Economics* **58**(1): 1–18.

Madsen, J. B. (2009). Trade Barriers, Openness, and Economic Growth, *Southern Economic Journal* **76**(2): 397–418.

Mankiw, N. G., Romer, D. and Weil, D. N. (1992). A Contribution to the Empirics of Economic Growth, *The Quarterly Journal of Economics* **107**(2): 407–437.

Mayer, T. and Zignago, S. (2011). Notes on CEPII's distances measures: the GeoDist Database, *Working Paper 2011-25*, CEPII.

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity, *Econometrica* **71**(6): 1695–1725.

Noguer, M. and Siscart, M. (2005). Trade raises income: a precise and robust result, *Journal of International Economics* **65**(2): 447–460.

Ortega, F. and Peri, G. (2014). Openness and income: The roles of trade and migration, *Journal of International Economics* **92**(2): 231–251.

Parente, P. M. D. C. and Santos Silva, J. M. C. (2012). A cautionary note on tests of overidentifying restrictions, *Economics Letters* **115**(2): 314–317.

Pascali, L. (2017). The Wind of Change: Maritime Technology, Trade, and Economic Development, *American Economic Review* **107**(9): 2821–2854.

Rodriguez, F. and Rodrik, D. (2001). Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence, *NBER Macroeconomics Annual 2000*, Vol. 15, MIT PRess, pp. 261–338.

Santos Silva, J. M. C. and Tenreyro, S. (2006). The Log of Gravity, *The Review of Economics and Statistics* **88**(4): 641–658.

3A Data

3A.1 Bilateral data set

The bilateral data set includes bilateral data for the 98 countries from the Mankiw (1992) sample and 162 partner countries, i.e., each country has 161 partners. Despite relevant data available for a larger set of partner countries, the analysis follows FR and limits partner countries outside the sample to those countries whose population is greater than 100,000.

The 98 countries in the Mankiw (1992) sample include: Algeria, Angola, Argentina, Australia, Austria, Bangladesh, Belgium, Benin, Bolivia, **Botswana**, Brazil, Burkina Faso, Burundi, Cameroon, Canada, Central African Republic, Chad, Chile, Colombia, Congo, Costa Rica, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Finland, France, Germany (unified), Ghana, Greece, Guatemala, Haiti, Honduras, Hong Kong, India, Indonesia, Ireland, Israel, Italy, Ivory Coast, Jamaica, Japan, Jordan, Kenya, South Korea, Liberia, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Morocco, Mozambique, Myanmar, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Portugal, Rwanda, Senegal, Sierra Leone, Singapore, Somalia, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syria, Tanzania, Thailand, Togo, Trinidad & Tobago, Tunisia, Turkey, U.K., U.S.A., Uganda, Uruguay, Venezuela, Zaire, Zambia and Zimbabwe.

The 162 partner countries include the 98 countries listed in the previous paragraph and: Afghanistan, Albania, Bahamas, Bahrain, Barbados, Belize, Bhutan*, Brunei Darussalam, Bulgaria, Cambodia, Cape Verde, China, Comoros, Cuba, Cyprus, Czechoslovakia, Djibouti, East Timor*, Eritrea*, Equatorial Guinea, Fiji, French Polynesia*, Gabon, Gambia, Guinea, Guinea-Bissau, Guyana, Hungary, Iceland, Iran, Iraq, Kuwait, Laos, Lebanon, Libya, **Lesotho**, Luxembourg, Maldives, Malta, Mongolia, **Namibia**, New Caledonia, North Korea, Oman, Poland, Puerto Rico*, Qatar, Reunion, Romania, Sao Tome and Principe, Saudi Arabia, Solomon Islands, St. Lucia, St. Vincent & Grenadines, Suriname, **Swaziland**, Taiwan*, U.S.S.R., United Arab Emirates, Vanuatu, Vietnam, Western Samoa, Yemen and Yugoslavia.

In the country lists above, countries in bold font are non-reporting in the DOTS but enter our dataset because of the symmetry imposed on bilateral trade flows. There is no record of bilateral trade for countries that are starred. Bilateral trade data from the DOTS for the year 1985 is used to construct symmetric bilateral trade flows. Bilateral trade shares are calculated by dividing bilateral trade in nominal terms by the destination country's GDP. The latter is the product of real GDP per capita (base year 1985) and a country's population both from the Penn World Tables (PWT) Mark 5.6. The real bilateral trade share, used in the robustness analysis, is the sum of real bilateral export share and real bilateral import share. The real bilateral export share is the nominal export share (equal to nominal exports as a share of GDP) divided by the reporter country's ratio of price level of exports to its price level of Output-side GDP. To get the real bilateral import share, the nominal import share is divided by the reporter's ratio of price level of imports to the price level of Output-side GDP. More formally:

$$\textit{real bilateral trade share}_{ji} = \frac{exports_{ji}/GDP_i}{pl_{exports,i}/pl_{GDP_i^o}} + \frac{imports_{ji}/GDP_i}{pl_{imports,i}/pl_{GDP_i^o}}$$

All data for price levels ($pl_{x,i}$) are sourced from PWT version 9.0. The data set is completed with data on area, bilateral distance, border and landlocked status from the CEPII *GeoDist* database. Population data are from the PWT Mark 5.6 and, when missing, the World Development Indicators (WDI).

3A.2 Country data set

Real income per capita, trade openness as well as population data are taken from PWT Mark5.6. Area is sourced from CEPII. PWT v9.0 is the source for real GDP^E per capita, and the real export share and import share for 1985.

Data on the percentage of land or population in the tropics, and continents is from the Centre for International Development (CID). Latitude and distance to the equator are sourced from the CEPII. Legal origin is from La Porta et al. (2008) and, when missing, from the CIA World Factbook. The index of ethno-linguistic fractionalization is from Easterly and Levine (1997). Data on constraint on executive is from the Polity IV Project (2014). Finally, data on corruption and the quality of governance come from the International Country Risky Guide (ICRG) provided by the Political Risk Services Group.

3A.3 Extended country sample

The extended sample consists of 147 countries and 166 partner countries. The extended sample includes four countries with populations less than 100,000 in 1985. They are Dominica, Grenada, Seychelles and Tonga.

Countries in the 147 sample include the 98 countries in the Mankiw (1992) sample and: Bahamas, Bahrain, Barbados, Belize, Bulgaria, Cape Verde, China, Comoros, Cyprus, Czechoslovakia, Djibouti, Dominica, Fiji, Gabon, Gambia, Grenada, Guinea, Guinea-Bissau, Guyana, Hungary, Iceland, Iran, Iraq, Kuwait, Laos, **Lesotho**, Luxembourg, Malta, Mongolia, **Namibia**, Oman, Poland, Qatar, Reunion, Romania, Saudi Arabia, Seychelles, Solomon Islands, St.Lucia, St.Vincent & Grenadines, Suriname, **Swaziland**, Tonga, U.S.S.R., United Arab Emirates, Vanuatu, Western Samoa, Yemen, Yugoslavia.

The partner countries include the 147 countries listed above and: Afghanistan, Albania, Bhutan*, Brunei Darussalam, Cambodia, Cuba, East Timor*, Eritrea*, Equatorial Guinea, French Polynesia*, Lebanon, Libya, Maldives, New Caledonia, North Korea, Puerto Rico*, Sao Tome and Principe, Taiwan* and Vietnam.

In the country lists above, countries in bold font are non-reporting in the DOTS but enter our dataset because of the symmetry imposed on bilateral trade flows. There is no record of bilateral trade for countries that are starred.

References to Appendix

Easterly, W., Levine, R., (1997). Africa's Growth Tragedy: Policies and Ethnic Divisions, *Quarterly Journal of Economics* **112**: 1203–1250.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., (2008). The Economic Consequences of Legal Origins, *Journal of Economic Literature* **46**: 285–332.

Mankiw, N.G., Romer, D., Weil, D.N., (1992). A Contribution to the Empirics of Economic Growth, *Quarterly Journal of Economics* **107**: 407–437.

Mayer, T., Zignago, S., (2011). Notes on CEPII's Distances Measures: the GeoDist Database, *CEPII Working Papers 2011-25*, CEPII.

Polity IV Project, (2014). Polity IV Project, Political Regime Characteristics and Transitions, 1800-2015. *Centre for Systemic Peace*, Virginia.

Table A1. Overview of variables used in the analysis

Variable	Description
Real GDP per capita	Real GDP per capita, chain weighted, US$, base year=1985.
Population	Total population.
Area	Area in km2.
Bilateral Trade	Sum of bilateral exports and imports, in millions of US$.
Distance	Distance between two main cities, weighted for the geographic distribution of the population within the country, in km.
Landlocked	Dummy variable set equal to 1 for landlocked countries.
Border	Dummy variable set equal to 1 for country pairs sharing a border.
Latitude	Calculated as the latitude of the main city, scaled to take values between -1 and 1.
Distance to the equator	Calculated using the absolute value of the latitude, scaled to take values between 0 and 1.
% Land in tropics	The percentage of land area located in the tropics.
Continental Dummies	Dummy variables for Latin America, Sub-Saharan Africa, and East Asia.
% Population in tropics	The percentage of the population living in a tropical area.
ICRG index	An index constructed as the sum of five variables: corruption, bureaucratic quality and rule of law, each multiplied by 5/3, as well as repudiation of contracts and expropriation risk. The index is normalized to vary between 0 and 1.
Corruption	Assessment of corruption within the political system; rescaled to take values between 0 and 1.
Executive constraint	Index of the extent to which decision making power of the executive is constrained by institutionalized procedure.
Ethno-linguistic fractionalization	Index that measures the probability that two randomly selected people from a given country do not belong to the same ethno-linguistic group.

Table A1. Overview of variables used in the analysis

Variable	Description
Legal origin	Variable that takes on 1 if a country's legal origin is English, 2 if it is French, 3 if it is German and 4 if it is Scandinavian.

3B Full results for Table 3

Table B1. Estimates of the Income Equation using Randomized Instruments: Full Results

Second-stage results:	Model (1)		Model (2)		Model (3)		Model (4)	
	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$
Trade share$_i$	-4.000	6.691	2.266	3.632	0.531	4.289	-1.938	6.062
	(88.754)	(0.892)	(89.180)	(0.676)	(62.945)	(0.715)	(66.014)	(1.297)
	[9]	[1000]	[7]	[997]	[11]	[1000]	[8]	[983]
	{1}	{1000}	{2}	{989}	{3}	{997}	{3}	{960}
ln $Population_i$	-0.078	0.683	0.242	0.352	0.064	0.373	-0.433	0.766
	(6.317)	(0.064)	(7.185)	(0.055)	(5.185)	(0.059)	(9.893)	(0.194)
	[125]	[1000]	[7]	[962]	[3]	[940]	[0]	[948]
	{64}	{1000}	{1}	{343}	{0}	{139}	{0}	{857}
ln $Area_i$	-0.631	0.553	0.096	0.244	-0.093	0.315	-0.137	0.399
	(9.832)	(0.099)	(9.662)	(0.073)	(6.834)	(0.078)	(4.429)	(0.087)
	[3]	[505]	[21]	[540]	[11]	[608]	[0]	[755]
	{0}	{19}	{6}	{38}	{4}	{68}	{0}	{162}
Distance to equator$_i$			3.692	3.314				
			(24.668)	(0.187)				
			[644]	[992]				
			{607}	{990}				
% Land in tropics$_i$					-1.59	-1.219		
					(6.211)	(0.071)		
					[647]	[994]		
					{604}	{991}		
Sub-Saharan Africa$_i$							-2.313	-1.029
							(10.594)	(0.208)
							[570]	[834]
							{521}	{727}
East Asia$_i$							0.448	-2.803
							(26.826)	(0.527)
							[41]	[961]
							{15}	{890}
Latin America$_i$							-1.358	0.996
							(19.428)	(0.382)
							[54]	[188]
							{22}	{0}
Obs.	98	98	98	98	98	98	98	98

Notes. The table reports average values from 1000 replications. The standard deviation of this average is reported in parentheses. For the estimated coefficients, the number of replications that produce an estimate significant at least at the 10% level is in [square brackets] and the number of replications in which the estimate is significant at least at the 5% level is in {curly brackets}.

3C Regressions of the Income Equation with Various Controls

Table C1. Estimates of the Income Equation using Actual Data: Additional Controls Included

Second-stage results:	**Model (5)**		**Model (6)**		**Model (7)**		**Model (8)**		**Model (9)**	
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$
Trade share$_i$	0.693*	1.023***	0.613	1.078***	0.451	0.710**	0.524	0.909***	0.841*	1.110***
	(0.386)	(0.353)	(0.440)	(0.407)	(0.329)	(0.288)	(0.379)	(0.330)	(0.490)	(0.413)
ln $Population_i$	-0.03	0.001	0.067	0.108	0.006	0.028	-0.026	0.01	-0.024	0.017
	(0.077)	(0.081)	(0.085)	(0.088)	(0.066)	(0.066)	(0.073)	(0.076)	(0.097)	(0.090)
ln $Area_i$	0.146**	0.176**	-0.081	-0.033	0.026	0.053	0.06	0.097	0.124*	0.140**
	(0.070)	(0.071)	(0.083)	(0.082)	(0.063)	(0.063)	(0.069)	(0.069)	(0.069)	(0.070)
Latitude$_i$	0.609**	0.568**	0.058	0.01			0.212	0.169	0.296	0.28
	(0.273)	(0.287)	(0.328)	(0.339)			(0.260)	(0.271)	(0.379)	(0.396)
% Population in tropics$_i$	-2.012***	-1.979***			-1.304***	-1.290***	-1.480***	-1.447***	-1.293***	-1.276***
	(0.203)	(0.208)			(0.219)	(0.222)	(0.225)	(0.232)	(0.285)	(0.284)
Distance to equator$_i$					2.483***	2.431***				
					(0.368)	(0.370)				
% Land in tropics$_i$			-1.565***	-1.533***			-0.719***	-0.712***		
			(0.186)	(0.185)			(0.206)	(0.207)		
Sub-Saharan Africa$_i$									-0.865***	-0.839**
									(0.329)	(0.333)
East Asia$_i$									-0.413	-0.529
									(0.394)	(0.374)
Latin America$_i$									-0.123	-0.054
									(0.312)	(0.303)
Observations	98	98	98	98	98	98	98	98	98	98
First-stage regressions:										
$\widehat{T}_i$	8.655***	9.554***	8.853***	9.659***	7.602***	8.487***	8.825***	9.649***	7.364***	8.597***
	(2.216)	(2.302)	(2.211)	(2.294)	(1.935)	(2.091)	(2.222)	(2.327)	(1.787)	(1.831)
Partial R^2	0.31	0.369	0.317	0.374	0.282	0.336	0.315	0.371	0.244	0.328
KP rk Wald F-stat	15.253	17.223	16.04	17.734	15.431	16.468	15.774	17.193	16.988	22.057

Note. The dependent variable is log of real GDP per capita reported by PWT Mark 5.6 for the year 1985. Heteroscedastic consistent standard errors are in parentheses. The standard errors in the second-stage are corrected for the errors created from the generated regressors. $\widehat{T}_i^{IS}$ is the predicted trade openness based on in-sample observations only. $\widehat{T}_i^{IS}$ is the predicted trade openness based on the total sample, i.e., including out-of-sample predictions. The KP rk Wald F-stat is the Kleibergen-Paap rk Wald F-statistic. Exogenous variables are included in the first-stage regressions but not shown. *,**, *** Significant at 10, 5 and 1 percent, respectively.

Table C2. Estimates of the Income Equation using Actual Data: Additional Controls Included

Second-stage results:	**Model (10)**		**Model (11)**		**Model (12)**		**Model (13)**		**Model (14)**	
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$
Trade share$_i$	.133	.356	.094	.396	.782**	.895***	.773*	1.099***	.823**	1.097***
	(0.351)	(0.322)	(0.402)	(0.346)	(0.306)	(0.284)	(0.406)	(0.377)	(0.393)	(0.352)
Ln population$_i$	-0.066	-0.058	-0.043	-0.034	-0.007	.005	.032	.062	.021	.051
	(0.053)	(0.054)	(0.058)	(0.058)	(0.077)	(0.077)	(0.078)	(0.083)	(0.087)	(0.091)
Ln area$_i$	.074	.108	.066	.112	.132**	.140**	.146*	.178**	.137**	.159**
	(0.070)	(0.069)	(0.083)	(0.077)	(0.059)	(0.060)	(0.076)	(0.077)	(0.069)	(0.070)
Latitude$_i$	.255	.287	.450**	.475**	.500**	.483**	.477*	.426	.322	.258
	(0.189)	(0.198)	(0.221)	(0.224)	(0.209)	(0.213)	(0.278)	(0.289)	(0.323)	(0.335)
% Population in tropics$_i$	-1.499***	-1.527***	-1.622***	-1.647***	-1.268***	-1.261***	-1.715***	-1.661***	-1.944***	-1.915***
	(0.182)	(0.180)	(0.203)	(0.198)	(0.207)	(0.209)	(0.254)	(0.255)	(0.221)	(0.226)
IGRC-Index$_i$	2.425***	2.259***								
	(0.343)	(0.354)								
Corruption$_i$			1.669***	1.520***						
			(0.278)	(0.277)						
Executive constraint$_i$					.210***	.210***				
					(0.027)	(0.028)				
Ethno-ling. fract.$_i$							-0.716**	-0.785**		
							(0.319)	(0.319)		
Legal Origin$_i$									.230*	.255**
									(0.119)	(0.119)
Observations	90	90	90	90	94	94	95	95	96	96
First-stage regressions:										
	6.812***	7.614***	6.996***	8.003***	8.063***	8.949***	8.786***	9.748***	8.895***	9.813***
	(1.708)	(1.903)	(1.679)	(1.842)	(2.675)	(2.859)	(2.204)	(2.297)	(2.220)	(2.277)
Partial R^2	.238	.279	.228	.281	.273	.328	.319	.383	.334	.399
KP *rk* Wald F-stat	15.905	16.017	17.363	18.884	9.084	9.797	15.89	18.013	16.053	18.578

Note. The dependent variable is log of real GDP per capita reported by PWT Mark 5.6 for the year 1985. Heteroscedastic consistent standard errors are in parentheses. The standard errors in the second-stage are corrected for the errors created from the generated regressors. $\widehat{T}_i^{IS}$ is the predicted trade openness based on in-sample observations only. $\widehat{T}_i^{IS}$ is the predicted trade openness based on the total sample, i.e., including out-of-sample predictions. The KP *rk* Wald F-stat is the Kleibergen-Paap *rk* Wald F-statistic. Exogenous variables are included in the first-stage regressions but not shown. *,**, *** Significant at 10, 5 and 1 percent, respectively.

Table C3. Estimates of the Income Equation using Randomized Instruments: Additional Controls Included

Second-stage results:	**Model (5)**		**Model (6)**		**Model (7)**		**Model (8)**		**Model (9)**	
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$
Trade share$_i$	7.533	4.176	2.925	4.407	-2.988	3.302	0.946	3.83	1.954	5.601
	(213.193)	(0.751)	(86.356)	(0.766)	(115.918)	(0.611)	(36.876)	(0.693)	(34.725)	(1.266)
	[7]	[999]	[10]	[1000]	[9]	[998]	[9]	[999]	[11]	[981]
	{2}	{992}	{3}	{994}	{1}	{989}	{2}	{992}	{2}	{958}
ln $Population_i$	0.613	0.298	0.272	0.403	-0.285	0.247	0.013	0.283	0.145	0.699
	(20.039)	(0.071)	(7.643)	(0.068)	(9.799)	(0.052)	(3.449)	(0.065)	(5.273)	(0.192)
	[0]	[1]	[1]	[549]	[0]	[10]	[0]	[1]	[0]	[914]
	{0}	{0}	{0}	{1}	{0}	{0}	{0}	{0}	{0}	{716}
ln $Area_i$	0.776	0.467	0.156	0.309	-0.328	0.319	0.1	0.371	0.192	0.417
	(19.664)	(0.069)	(8.876)	(0.079)	(11.914)	(0.063)	(3.463)	(0.065)	(2.139)	(0.078)
	[44]	[993]	[9]	[351]	[0]	[991]	[3]	[973]	[40]	[856]
	{12}	{953}	{2}	{6}	{0}	{939}	{0}	{834}	{4}	{316}
Latitude$_i$	-0.232	0.18	-0.183	-0.338			0.165	-0.161	0.23	0.017
	(26.225)	(0.092)	(9.017)	(0.080)			(4.164)	(0.078)	(2.037)	(0.074)
	[247]	[0]	[0]	[0]			[0]	[0]	[0]	[0]
	{123}	{0}	{0}	{0}			{0}	{0}	{0}	{0}
% Population in tropics$_i$	-1.326	-1.663			-1.501	-1.141	-1.444	-1.192	-1.224	-0.998
	(21.392)	(0.075)			(6.632)	(0.035)	(3.211)	(0.060)	(2.150)	(0.078)
	[694]	[998]			[701]	[988]	[653]	[968]	[655]	[344]
	{656}	{993}			{658}	{970}	{608}	{894}	{606}	{152}
Distance to equator$_i$					3.176	1.908				
					(23.366)	(0.123)				
					[587]	[818]				
					{536}	{468}				
% Land in tropics$_i$			-1.409	-1.309			-0.712	-0.662		
			(5.826)	(0.052)			(0.641)	(0.012)		
			[704]	[999]			[653]	[579]		
			{682}	{995}			{585}	{155}		

Continues

Second-stage results:	Model (5)		Model (6)		Model (7)		Model (8)		Model (9)	
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$
Sub-Saharan Africa$_i$									-0.758	-0.408
									(3.334)	(0.122)
									[419]	[1]
									{306}	{0}
East Asia$_i$									-0.895	-2.474
									(15.041)	(0.549)
									[4]	[963]
									{0}	{870}
Latin America$_i$									.163	1.101
									(8.932)	(0.326)
									[0]	[121]
									{0}	{0}
Observations	98	98	98	98	98	98	98	98	98	98
First stage regressions:										
	6.645	27.75	6.396	28.326	6.785	30.22	6.661	28.578	6.153	20.743
	(26.091)	(5.795)	(25.892)	(5.663)	(26.004)	(6.490)	(26.252)	(5.962)	(24.938)	(4.754)
	[109]	[998]	[109]	[998]	[111]	[997]	[110]	[997]	[117]	[978]
	{59}	{986}	{64}	{988}	{61}	{977}	{60}	{987}	{63}	{935}
Partial R^2	.013	.105	.013	.11	.013	.111	.013	.107	.013	.072
	(0.019)	(0.031)	(0.019)	(0.032)	(0.019)	(0.033)	(0.020)	(0.032)	(0.019)	(0.027)
KP rk Wald F-stat	1.156	10.928	1.145	11.415	1.153	9.66	1.153	10.819	1.197	9.924
	<5>	<624>	<4>	<681>	<6>	<464>	<5>	<611>	<6>	<487>
CD Wald F-stat	1.235	10.928	1.218	11.556	1.232	11.66	1.234	11.068	1.217	6.944

Note. The table reports average values from 1000 replications. The standard deviation of this average is reported in parentheses. For the estimated coefficients, the number of replications that produce an estimate significant at least at the 10% level is in [square brackets] and the number of replications in which the estimate is significant at least at the 5% level is in {curly brackets}. The number of times the KP rk Wald F-stat is greater than 10 is in <angle brackets>. Exogenous variables are included in the first stage regressions but not shown.

Table C4. Estimates of the Income Equation using Randomized Instruments: Additional Controls Included

Second-stage results:	**Model (10)**		**Model (11)**		**Model (12)**		**Model (13)**		**Model (14)**	
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$
Trade share$_i$	-1.294	6.503	-2.268	4.353	-2.285	2.992	-0.822	3.921	.774	4.006
	(30.720)	(35.110)	(94.978)	(2.799)	(76.557)	(0.656)	(50.191)	(0.703)	(97.508)	(0.683)
	[0]	[473]	[1]	[874]	[11]	[988]	[7]	[999]	[6]	[998]
	{0}	{173}	{0}	{764}	{1}	{957}	{2}	{991}	{3}	{992}
ln $Population_i$	-0.117	.16	-0.11	.079	-0.333	.229	-0.115	.323	.016	.371
	(1.091)	(1.246)	(2.712)	(0.080)	(8.153)	(0.070)	(4.643)	(0.065)	(10.710)	(0.075)
	[0]	[0]	[0]	[0]	[0]	[0]	[0]	[6]	[0]	[151]
	{0}	{0}	{0}	{0}	{0}	{0}	{0}	{0}	{0}	{1}
ln $Area_i$	-0.142	1.041	-0.293	.713	-0.088	.291	-0.011	.457	.133	.397
	(4.662)	(5.328)	(14.434)	(0.425)	(5.498)	(0.047)	(4.955)	(0.069)	(7.957)	(0.056)
	[1]	[451]	[5]	[840]	[67]	[968]	[35]	[992]	[35]	[991]
	{0}	{186}	{0}	{678}	{21}	{827}	{8}	{961}	{5}	{936}
Latitude$_i$	.046	1.187	.255	.8	.947	.177	.729	-0.02	.333	-0.415
	(4.495)	(5.138)	(7.818)	(0.230)	(11.172)	(0.096)	(7.921)	(0.111)	(22.573)	(0.158)
	[0]	[0]	[193]	[17]	[234]	[0]	[74]	[0]	[2]	[0]
	{0}	{0}	{38}	{0}	{141}	{0}	{6}	{0}	{0}	{0}
% Population in tropics$_i$	-1.319	-2.302	-1.425	-1.977	-1.454	-1.133	-1.976	-1.199	-1.949	-1.601
	(3.873)	(4.426)	(7.925)	(0.234)	(4.646)	(0.040)	(8.223)	(0.115)	(10.496)	(0.073)
	[631]	[888]	[716]	[979]	[722]	[994]	[585]	[967]	[685]	[998]
	{585}	{866}	{687}	{973}	{691}	{989}	{541}	{939}	{653}	{996}
IGRC-Index$_i$	3.489	-2.322								
	(22.895)	(26.166)								
	[291]	[14]								
	{226}	{6}								
Corruption$_i$			2.833	-0.431						
			(46.828)	(1.380)						
			[253]	[6]						
			{196}	{5}						

Continues

Second-stage results:	**Model (10)**		**Model (11)**		**Model (12)**		**Model (13)**		**Model (14)**	
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{IS}$
Executive constraint$_i$					.231	.196				
					(0.508)	(0.004)				
					[773]	[999]				
					{741}	{997}				
Ethno-ling. fract.$_i$							-0.378	-1.384		
							(10.640)	(0.149)		
							[172]	[999]		
							{77}	{985}		
Legal Origin$_i$									.226	.514
									(8.704)	(0.061)
									[87]	[999]
									{22}	{995}
Observations	90	90	90	90	94	94	95	95	96	96
First-stage regressions:										
	3.123	14.443	3.651	20.131	6.694	27.736	6.177	28.711	6.584	28.198
	(24.242)	(5.918)	(25.086)	(6.145)	(26.033)	(6.481)	(27.032)	(6.138)	(26.167)	(5.747)
	[106]	[463]	[113]	[865]	[115]	[977]	[106]	[995]	[114]	[997]
	{55}	{202}	{62}	{755}	{55}	{893}	{54}	{984}	{55}	{989}
Partial R^2	.013	.03	.013	.056	.014	.096	.013	.11	.013	.11
	(0.019)	(0.020)	(0.019)	(0.026)	(0.020)	(0.033)	(0.020)	(0.033)	(0.020)	(0.032)
KP *rk* Wald F-stat	1.095	2.762	1.135	5.891	1.157	6.097	1.133	11.103	1.151	10.555
	<3>	<2>	<2>	<63>	<3>	<22>	<3>	<633>	<3>	<594>

Note. The table reports average values from 1000 replications. The standard deviation of this average is reported in parentheses. For the estimated coefficients, the number of replications that produce an estimate significant at least at the 10% level is in [square brackets] and the number of replications in which the estimate is significant at least at the 5% level is in {curly brackets}. The number of times the KP *rk* Wald F-stat is greater than 10 is in <angle brackets>. Exogenous variables are included in the first stage regressions but not shown.

3D Additional Results

Table D1. Estimates of the Income Equation using Actual Data: Additional Controls Included with a Larger Sample of Countries

Second-stage results:	**Model (5)**	**Model (6)**	**Model (7)**	**Model (8)**	**Model (9)**
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$
Trade share$_i$	1.451***	0.789	1.483**	1.279**	1.244**
	(0.497)	(0.525)	(0.677)	(0.514)	(0.491)
$\ln Population_i$	-0.026	0.02	0.029	-0.024	-0.006
	(0.089)	(0.071)	(0.095)	(0.086)	(0.093)
$\ln Area_i$	0.219***	-0.005	0.151*	0.168**	0.151**
	(0.080)	(0.066)	(0.090)	(0.085)	(0.069)
Latitude$_i$	0.762**	0.407		0.535	0.161
	(0.307)	(0.352)		(0.354)	(0.343)
% Population in tropics$_i$	-1.738***		-1.247***	-1.379***	-1.112***
	(0.227)		(0.254)	(0.248)	(0.249)
Distance to equator$_i$			1.869***		
			(0.461)		
% Land in tropics$_i$		-1.253***		-0.457*	
		(0.217)		(0.260)	
Sub-Saharan Africa$_i$					-1.058***
					(0.256)
East Asia$_i$					-0.610*
					(0.352)
Latin America$_i$					-0.163
					(0.253)
Obs.	128	146	128	128	128
First-stage regressions:					
$\widehat{T}_i$	4.499***	3.758***	3.745***	4.519***	4.172***
	(1.039)	(0.911)	(0.996)	(1.102)	(0.877)
Partial R^2	0.176	0.144	0.144	0.173	0.145
KP *rk* Wald F-stat	18.742	17.023	14.15	16.811	22.619

Note. The dependent variable is log of real GDP per capita reported by PWT Mark 5.6 for the year 1985. Heteroscedastic consistent standard errors are in parentheses. The standard errors in the second-stage are corrected for the errors created from the generated regressors. $\widehat{T}_i^{TS}$ is the predicted trade openness based on the total sample; i.e., including out-of-sample predictions. The KP *rk* Wald F-stat is the Kleibergen-Paap *rk* Wald F-statistic. Exogenous variables are included in the first-stage first-stage regressions but not shown. *, **, *** Significant at 10, 5 and 1 percent, respectively.

Table D1. (Cont'd)

Second-stage results:	**Model (10)**	**Model (11)**	**Model (12)**	**Model (13)**	**Model (14)**
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$
Trade share$_i$	0.77	0.841*	1.415**	1.139***	1.588***
	(0.531)	(0.504)	(0.688)	(0.413)	(0.558)
$\ln Population_i$	-0.168***	-0.157***	-0.05	0.029	0.007
	(0.057)	(0.057)	(0.109)	(0.074)	(0.103)
$\ln Area_i$	0.222**	0.226**	0.223***	0.208**	0.215**
	(0.090)	(0.093)	(0.082)	(0.083)	(0.084)
Latitude$_i$	0.486**	0.605***	0.699***	0.668**	0.525
	(0.212)	(0.217)	(0.264)	(0.299)	(0.350)
% Population in tropics$_i$	-1.681***	-1.755***	-1.282***	-1.617***	-1.689***
	(0.214)	(0.213)	(0.239)	(0.266)	(0.246)
IGRC-Index$_i$	1.622***				
	(0.516)				
Corruption$_i$		1.069***			
		(0.359)			
Executive constraint$_i$			0.167***		
			(0.032)		
Ethno-ling. fract.$_i$				-0.743**	
				(0.299)	
Legal Origin$_i$					0.185
					(0.123)
Obs.	112	112	121	104	124
First-stage regressions:					
$\widehat{T}_i$	3.810***	3.955***	3.815***	5.042***	4.445***
	(0.840)	(0.807)	(1.101)	(1.216)	(1.047)
Partial R^2	0.168	0.169	0.138	0.226	0.174
KP *rk* Wald F-stat	20.565	24.026	11.998	17.185	18.015

Note. The dependent variable is log of real GDP per capita reported by PWT Mark 5.6 for the year 1985. Heteroscedastic consistent standard errors are in parentheses. The standard errors in the second-stage are corrected for the errors created from the generated regressors. $\widehat{T}_i^{TS}$ is the predicted trade openness based on the total sample; i.e., including out-of-sample predictions. The KP *rk* Wald F-stat is the Kleibergen-Paap *rk* Wald F-statistic. Exogenous variables are included in the first-stage first-stage regressions but not shown. *, **, *** Significant at 10, 5 and 1 percent, respectively.

Table D2. Estimates of Income Equation using Randomized Instruments: Larger Sample of Countries

Second-stage results:	Model (1)		Model (2)		Model (3)		Model (4)	
	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$
Trade share$_i$	1.335	6.638	-2.71	4.561	1.889	5.267	2.111	4.697
	(82.041)	(0.628)	(71.290)	(0.593)	(64.782)	(0.668)	(42.970)	(0.501)
	[8]	[1000]	[5]	[998]	[3]	[998]	[6]	[1000]
	{1}	{1000}	{0}	{993}	{0}	{994}	{3}	{1000}
Ln population$_i$	0.205	0.591	-0.235	0.364	0.133	0.424	0.198	0.485
	(5.965)	(0.046)	(5.873)	(0.049)	(5.591)	(0.058)	(4.771)	(0.056)
	[31]	[1000]	[0]	[25]	[0]	[9]	[1]	[1000]
	{6}	{980}	{0}	{0}	{0}	{0}	{0}	{988}
Ln area$_i$	-0.014	0.417	-0.303	0.269	0.066	0.327	0.115	0.272
	(6.671)	(0.051)	(5.606)	(0.047)	(4.993)	(0.051)	(2.622)	(0.031)
	[2]	[959]	[3]	[935]	[2]	[921]	[2]	[999]
	{0}	{145}	{1}	{141}	{0}	{65}	{0}	{938}
Distance to equator$_i$			4.844	2.507				
			(22.909)	(0.191)				
			[581]	[957]				
			{537}	{855}				
% Land in tropics$_i$					-1.223	-0.743		
					(9.200)	(0.095)		
					[541]	[294]		
					{481}	{102}		
Sub-Saharan Africa$_i$							-1.511	-1.284
							(3.779)	(0.044)
							[693]	[1000]
							{660}	{1000}
East Asia$_i$							-1.114	-1.966
							(14.155)	(0.165)
							[58]	[1000]
							{25}	{911}
Latin America$_i$							-0.248	0.191
							(7.287)	(0.085)
							[117]	[0]
							{60}	{0}
Observations	147	147	147	147	146	146	147	147
First-stage regression (selected results):								
$\tilde{T}_i$	3.343	21.61	3.168	21.744	3.092	19.975	3.102	22.049
	(21.410)	(2.713)	(20.721)	(3.436)	(20.878)	(3.003)	(20.485)	(3.179)
	[115]	[1000]	[105]	[998]	[106]	[998]	[108]	[1000]
	{57}	{1000}	{56}	{984}	{57}	{994}	{52}	{1000}
Partial R^2	0.007	0.107	0.007	0.082	0.007	0.077	0.008	0.099
	(0.011)	(0.018)	(0.011)	(0.019)	(0.011)	(0.018)	(0.011)	(0.019)
KP rk Wald F-stat	1.079	15.081	1.055	7.015	1.044	7.448	1.114	12.268
	<4>	<976>	<3>	<20>	<2>	<31>	<4>	<844>

Notes. The table reports average values from 1000 replications. The standard deviation of this average is reported in parentheses. For the estimated coefficients, the number of replications that produce an estimate significant at least at the 10% level is in [square brackets] and the number of replications in which the estimate is significant at least at the 5% level is in {curly brackets}. The number of times the KP rk Wald F-stat is greater than 10 is in <angle brackets>. Exogenous variables are included in the first stage regressions but not shown.

Table D3. Estimates of the Income Equation using Actual Data: Additional Controls Included, using Real Trade Openness and GDP$^{\mathrm{E}}$

Second-stage results:	**Model (5)**	**Model (6)**	**Model (7)**	**Model (8)**	**Model (9)**
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$
Real Trade share$_i$	0.888*	0.863*	0.798*	0.753	0.928*
	(0.461)	(0.493)	(0.419)	(0.470)	(0.540)
$\ln Population_i$	-0.069	0.02	-0.001	-0.055	-0.096
	(0.087)	(0.088)	(0.084)	(0.086)	(0.113)
$\ln Area_i$	0.189***	0.007	0.079	0.112	0.182**
	(0.072)	(0.087)	(0.072)	(0.075)	(0.072)
Latitude$_i$	0.740**	0.264		0.386	0.557
	(0.321)	(0.325)		(0.290)	(0.415)
% Population in tropics$_i$	-1.585***		-0.945***	-1.111***	-1.034***
	(0.238)		(0.257)	(0.273)	(0.401)
Distance to equator$_i$			2.344***		
			(0.466)		
% Land in tropics$_i$		-1.287***		-0.658***	
		(0.207)		(0.243)	
Sub-Saharan Africa$_i$					-0.649
					(0.432)
East Asia$_i$					-0.09
					(0.350)
Latin America$_i$					-0.076
					(0.380)
Obs.	96	96	96	96	96
First-stage regression (selected results):					
$\widehat{T}_i$	8.811***	9.025***	7.440***	8.879***	7.863***
	(2.449)	(2.455)	(2.161)	(2.467)	(2.079)
Partial R^2	0.3	0.303	0.255	0.3	0.243
KP *rk* Wald F-stat	12.945	13.51	11.849	12.954	14.304

Note. The country sample is the 98 sample excluding Papua New Guinea and Somalia, for which data are not available in PWT v9.0. $\widehat{T}_i$ is the predicted trade openness based on the total sample; i.e. including out-of-sample predictions. GDPE refers to the measure constructed using the expenditure-side GDP at current PPPs reported in PWT v9.0 for the year 1985. Real trade openness is from PWT v9.0. Heteroscedastic consistent standard errors are in parentheses. The standard errors in income regressions are corrected for the errors created from the generated regressors. The KP *rk* Wald F-stat is the Kleibergen-Paap *rk* Wald F-statistic. Exogenous variables are included in the first-stage regressions but not shown. *, **, *** Significant at 10, 5 and 1 percent, respectively.

Table D3. (Cont'd)

Second-stage results:	**Model (10)**	**Model (11)**	**Model (12)**	**Model (13)**	**Model (14)**
	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$	IV-$\widehat{T}_i^{TS}$
Real trade share$_i$	0.131	0.037	0.851***	0.985**	1.008**
	(0.404)	(0.486)	(0.321)	(0.477)	(0.464)
$\ln Population_i$	-0.086	-0.05	-0.057	0.001	-0.022
	(0.073)	(0.073)	(0.095)	(0.084)	(0.092)
$\ln Area_i$	0.084	0.064	0.171***	0.186**	0.178**
	(0.073)	(0.089)	(0.062)	(0.078)	(0.071)
Latitude$_i$	0.306	0.526*	0.664**	0.605*	0.536
	(0.236)	(0.269)	(0.261)	(0.337)	(0.395)
% Population in tropics$_i$	-1.070***	-1.183***	-0.816***	-1.266***	-1.495***
	(0.200)	(0.233)	(0.273)	(0.305)	(0.249)
IGRC-Index$_i$	2.872***				
	(0.455)				
Corruption$_i$		2.115***			
		(0.395)			
Executive constraint$_i$			0.211***		
			(0.037)		
Ethno-ling. fract.$_i$				-0.690**	
				(0.349)	
Legal Origin$_i$					0.167
					(0.125)
Obs.	88	88	92	93	95
First-stage regression (selected results):					
	7.028***	7.119***	8.687***	8.837***	8.998***
	(1.767)	(1.856)	(2.991)	(2.429)	(2.463)
Partial R^2	0.254	0.233	0.284	0.296	0.306
KP *rk* Wald F-stat	15.812	14.719	8.433	13.233	13.346

Note. The country sample is the 98 sample excluding Papua New Guinea and Somalia, for which data are not available in PWT v9.0. $\widehat{T}_i$ is the predicted trade openness based on the total sample; i.e. including out-of-sample predictions. GDP^{E} refers to the measure constructed using the expenditure-side GDP at current PPPs reported in PWT v9.0 for the year 1985. Real trade openness is from PWT v9.0. Heteroscedastic consistent standard errors are in parentheses. The standard errors in income regressions are corrected for the errors created from the generated regressors. The KP *rk* Wald F-stat is the Kleibergen-Paap *rk* Wald F-statistic.Exogenous variables are included in the first-stage regressions but not shown. *, **, *** Significant at 10, 5 and 1 percent, respectively.

Table D4. Estimates of Income Equation using Randomized Instruments: Real Trade Openness and GDP^{E}

Second-stage results:	Model (1)		Model (2)		Model (3)		Model (4)	
	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$	IV-$\tilde{T}_i^{TS}$	IV-$\tilde{T}_i^{IS}$
Real trade share$_i$	0.294	5.346	1.019	4.526	3.542	4.348	0.567	5.774
	(40.785)	(0.626)	(73.951)	(1.039)	(60.469)	(0.739)	(35.900)	(1.268)
	[48]	[1000]	[15]	[986]	[30]	[1000]	[32]	[989]
	{18}	{1000}	{3}	{947}	{6}	{998}	{11}	{977}
ln $Population_i$	0.169	0.289	0.08	0.233	0.158	0.194	-0.131	0.522
	(0.971)	(0.015)	(3.229)	(0.045)	(2.754)	(0.034)	(4.504)	(0.159)
	[177]	[176]	[0]	[0]	[0]	[0]	[0]	[776]
	{4}	{0}	{0}	{0}	{0}	{0}	{0}	{345}
ln $Area_i$	-0.101	0.496	0.008	0.407	0.298	0.39	0.09	0.416
	(4.816)	(0.074)	(8.410)	(0.118)	(6.912)	(0.084)	(2.245)	(0.079)
	[2]	[963]	[3]	[934]	[1]	[959]	[54]	[925]
	{0}	{767}	{0}	{820}	{0}	{841}	{11}	{753}
Distance to equator$_i$			3.47	1.21				
			(47.653)	(0.669)				
			[372]	[115]				
			{308}	{64}				
% Land in tropics$_i$					-0.825	-0.662		
					(12.213)	(0.149)		
					[431]	[639]		
					{367}	{381}		
Sub-Saharan Africa$_i$							-1.689	-0.204
							(10.243)	(0.362)
							[347]	[76]
							{281}	{40}
East Asia$_i$							-0.234	-1.974
							(11.998)	(0.424)
							[9]	[384]
							{1}	{79}
Latin America$_i$							-0.662	0.926
							(10.951)	(0.387)
							[32]	[361]
							{9}	{3}
Obs.	96	96	96	96	96	96	96	96
First-stage regressions:								
$\tilde{T}_i$	9.749	36.081	6.523	29.941	7.713	33.764	7.767	26.438
	(22.859)	(7.032)	(22.191)	(7.995)	(22.931)	(8.000)	(20.588)	(6.706)
	[140]	[1000]	[111]	[976]	[120]	[998]	[131]	[982]
	{72}	{1000}	{53}	{917}	{61}	{995}	{72}	{964}
Partial R^2	0.015	0.192	0.014	0.099	0.014	0.134	0.014	0.092
	(0.022)	(0.041)	(0.022)	(0.038)	(0.022)	(0.040)	(0.021)	(0.033)
KP rk Wald F-stat	1.262	30.716	1.129	7.107	1.197	16.284	1.283	14.082
	<1>	<992>	<0>	<97>	<0>	<863>	<2>	<728>

Notes. The table reports average values from 1000 replications. The standard deviation of this average is reported in parentheses. For the estimated coefficients, the number of replications that produce an estimate significant at least at the 10% level is in [square brackets] and the number of replications in which the estimate is significant at least at the 5% level is in {curly brackets}. The number of times KP rk Wald F-stat is greater than 10 is in <angle brackets>. Exogenous variables are included in the first stage regressions but not shown.

Chapter 4

Trade and Income: the Effects of Including Migration and Foreign Direct Investment

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Abstract
A major challenge when investigating how trade affects income in a cross-country analysis, is finding valid and strong instruments for trade. One solution is generating an instrumental variable based on geography to identify the variation of trade openness exogenous to income (Frankel and Romer, 1999). A prerequisite for this instrument's validity is that one controls for all other channels through which geography can affect income (Rodriguez and Rodrik, 2001). More recently Ortega and Peri (2014) make the case to include the channel of migration as it is also driven by geography. I argue in this paper that Foreign Direct Investment (FDI) should also be included because FDI affects income and the literature finds that, like trade and migration, FDI flows can be explained by the gravity model(Anderson, 2011) and thus geography. Using and expanding on the instrumentation strategy proposed by Frankel and Romer (1999) in the same way that Ortega and Peri (2014) do, I find that I cannot adequately identify the effect of trade, migration and FDI. This is caused by multicollinearity between the variables and the chosen instrumentation strategy. By using the same geographic explanatory variables to generate individual instruments for each regressor (trade, migration and FDI), each instrument essentially captures the same variation, that of the covariates in the bilateral equation. As a result, even when I am able to identify individual effects, I cannot interpret the estimates in the conventional sense to make statements on the relative importance of each regressor for explaining differences in income between countries.

JEL: F14, F43, F60
Key words: Globalization, International trade, international migration, Foreign Direct Investment(FDI), Growth

4.1 Introduction

The challenge for the empirical literature on trade's effect on income is to identify a valid instrumental variable.

One such instrument is a generated instrument variable proposed by Frankel and Romer (1999), henceforth FR. The generated instrumental variable is the predicted trade share using geographic characteristics as explanatory variables. As geography is not determined by income, the predicted trade share will capture the exogenous variation of trade. However, as Rodriguez and Rodrik (2001) point out, the predicted trade share is not a valid instrumental variable for trade in this setting unless all channels through which geography affects income are controlled for. Since then the literature identifies and controls for different channels such as institutions, agricultural productivity, propensity for tropical diseases.

Recently Ortega and Peri (2014), henceforth OP, argue that one of these channels one needs to control for is migration. Like trade, bilateral migration can be predicted accurately using the gravity model of trade (Mayda, 2010; Anderson, 2011) showing that geography is an important determinant for migration. Also like trade, migration affects income (Andersen and Dalgaard, 2011; Ortega and Peri, 2014). Therefore, not controlling for migration means that coefficients for trade are biased upward when using the FR instrumental variable.

In this paper I argue that the same reasoning can also be applied to Foreign Direct Investment. FDI affects income and, like migration and trade, FDI inflows can be predicted using the gravity model (Blonigen and Piger, 2014; Portes and Rey, 2005; Anderson, 2011). Therefore, not controlling for FDI along with migration, biases the estimated trade effect on income when using the FR instrument as the instrumental variable for trade.

The aim of this paper is to improve on the estimation of trade's effect on income using additional controls for migration and FDI as well as to investigate the effects of openness to migration on income. In this way I hope to contribute to the understanding of the size of the effect of trade's effect on income.

Methodologically, the starting point is the original methodology proposed by FR and I generate an instrumental variable for trade share using a bilateral trade equation based on the gravity model of trade. The equation of interest, a simple income regression estimating income per capita on country trade share and geographic controls, is expanded to include migration share and FDI share as additional controls.

A complication is that migration share and FDI share, like trade share, are endogenous to income. To instrument for migration share and FDI share, I follow Andersen and Dalgaard (2011) and OP and generate predicted migration share and predicted FDI share by estimating the specification that is identical to the specification used to generate the instrument for trade. The reason I can employ this instrumentation strategy for migration and FDI share because like bilateral trade, bilateral migration and bilateral FDI can be explained and predicted by the gravity model and its geographic determinants. The instruments are then used to estimate the simple income equation of income on trade, migration and FDI using a panel data set for OECD countries and four non-OECD countries, over the period 1993-2012. As a robustness test, I also present results from a larger sample of 166 countries for the period 2001-2010.[1]

The results reported on the individual effects of trade, migration and FDI on income are inconclusive. There is some evidence that one must control for migration when estimating the effect of trade on income, though no evidence that the same applies to controlling for FDI as the latter has no effect on the estimate for trade share. Also, the generated instrument for FDI is not a strong instrument.

One reason for the inconclusive results is the lack of within country variation over time due to the limited time span covered by the panel data. This is also a reason that when all three instruments are used simultaneously, the instruments are weak instruments for their associated regressors. Individually though, the instruments of predicted trade and predicted migration remain strong instruments for trade and migration, respectively. More often than not the instruments for trade and migration remain strong instruments when used together with another determinant. This, however, is not true for FDI.

The main contribution of the paper is to the literature on instrumentation strategies employed in the literature on globalization and growth. Using an identical specification to generate instruments for different regressors means that each individual instrument relies on the same variation of the covariates. Unless trade, migration and FDI react in a fundamentally different way to changes in the covariates, i.e. the estimated coefficients in the bilateral equation are very

[1] Availability of bilateral migration and bilateral FDI data is the main reason for the short time span.

different in sign, size and significance, the exogenous variation of each regressor is near identical hindering the identification of each regressor's effect on income. Even if the identification is achieved, this common source of variation means that it is subsequently impossible to interpret the estimates that are generated using these instrumental variables. Indeed, the interpretation of one estimate is dependent on the ability to hold all other determinants constant. This breaks down in cases where the variation for different variables is from a common source, the covariates in the bilateral equation.

Recognizing the limitations of this instrumentation strategy means that future research must employ fundamentally different instruments for each of the determinants, trade, migration and FDI to investigate their relative importance in explaining cross country variations in income.

The paper proceeds as follows. The next section is a review of the literature. This is followed by a methodological section and a description of the data in Section 4.4. All results are reported in Section 4.5. Section 4.6 is a discussion of results and Section 4.7 concludes.

4.2 Literature Review

The literature on globalization and income is extensive, especially for trade, and finds some empirical evidence that trade, migration and FDI individually are a positive contributor to income. The more recent literature has started to investigate more than one globalization flow to ascertain whether either trade or migration is the most important determinant of income (Ortega and Peri, 2014). This paper attempts to extend the analysis to include FDI.

The emergence of the endogenous growth theory allows for a more solid foundation of the identification of the effect of trade on income as it allowed for trade to have permanent effects on income (Edwards, 1993). The literature identifies several channels. Trade affects growth positively through efficiency gains as a result of technological improvements (Edwards, 1998), through the availability of foreign intermediates which lead to improvement of domestic production techniques (Estevadeordal and Taylor, 2013). Freund and Bolaky (2008) identify the positive effect of increased trade openness on income as arising from the improved allocation of resources towards the export sector.

Nevertheless, empirically identifying the relationship between trade and income is complicated by the presence of reverse causality. The literature identifies different instrumentation variables that are used to investigate this relationship.

One such instrumental variable for trade is the FR instrumental variable based on the gravity model of trade. The instrument, the predicted trade share, captures the variation caused by geographic characteristics of a country relative to its trading partners. It can be considered exogenous given that the geographic determinants of bilateral trade are not affected by income. Using their instrument, which can account for about 45% of variation of actual trade, FR find a positive relationship between trade openness and income.

However, an important condition for the validity of the instrument and the FR results is that trade is the only channel through which geography affects income and as Rodriguez and Rodrik (2001) point out this is not the case.

The literature identifies several channels. One such channel is institutions. Geography has been found to determine the quality of institutions which in turn plays a role in explaining cross-country differences in income (Hall and Jones, 1999; Easterly and Levine, 2003; Acemoglu et al., 2001; Rodrik et al., 2004). A direct channel is that country's geographic location and associated climate determines a location's propensity for the population to suffer from debilitating diseases. These affect not only the size of the working population but also its level of human capital and hence economic income (Madsen, 2016).

Rodriguez and Rodrik (2001) find that controlling for institutions, makes the estimated effect of trade insignificant. The result that trade is not significant once controlling for institutions using latitude is also found by Irwin and Terviö (2002) for different cross sections across the twentieth century. However, the later literature using improved data sets as well as different sets of controls find that trade is significantly different from zero (Noguer and Siscart, 2005).

The discussion about the size of trade's effect on income remains open. Using a instrumental variable constructed from a natural experiment (the closing of the Suez Canal in the 1960's) that allows him to directly identify the exogenous variation of trade in goods caused by distance,[2] Feyrer (2009a) finds that the size of the coefficient of trade on income is about a quarter of that found by FR. Feyrer therefore concludes that the larger impact found in the previous literature

[2]Feyrer shows that the closing of the Suez Canal in the late 1960's to early 1970's had large implications for shipping routes used, increasing trade costs and as a result the volume of the trade in goods. It is this exogenous shock, that allows him the direct effect of changes in bilateral distance on the volume of bilateral trade. The generated instrument of predicted trade therefore captures the exogenous variation of trade in goods caused by variations of bilateral distance better than the FR instrument.

can only partly be attributed to variation in the volume of trade; another part of this impact has to be attributed to other aspects of globalization, for instance, FDI and the cross-border transfer of knowledge through migration impact per capita income (Feyrer, 2009a).

More recently, OP propose that one should also control for migration when using the FR instrument. Their reasoning is as follows. Migration positively affects income, while at the same time migration flows are also determined by geographic characteristics of countries.

Migration can affect income in two ways. First by changes to labour supply. Not only does immigration (emigration) increase (decrease) the working age population, it also affects the level of human capital within an economy thus affecting income in the long run(Hanson, 2009). Secondly, the movement of people contributes to the flows of ideas and can contribute to cross-border technological diffusion in the same way as trade and FDI do.

The gravity model of trade can be applied to determine migration flows (Mayda, 2010; Anderson, 2011). For this reason, the predicted trade share as an instrumental variable in the structural regression may be capturing more than just the variation in the trade in goods. It may also be capturing the variations in migration and capital flows. The measure of bilateral trade (share) may be a proxy for economic integration not just trade.

So, OP's observation that not controlling for migration means that the estimated coefficient of trade is biased and may be overestimating the actual effect of trade in goods on income. Using the FR methodology to instrument for both trade and migration, OP find a positive effect of trade on income until migration is included in the structural analysis. Their results lead them conclude that migration is more important determinant of differences in income than trade as the effect of trade dissipates with the introduction of migration alongside the usual long-term determinants of income through geography. This confirms earlier findings by Andersen and Dalgaard (2011) that the more open countries are (i.e. the higher the ratio of in- and outflow of travelers to labour population is), the higher their income.

Similar to the case for migration, one can make the argument that the use of the FR instrument for trade requires controlling for FDI in the structural analysis as FDI alongside controls for migration and institutions.

The theory suggests FDI has a positive effect on economic growth. In an endogenous growth model, besides increasing the level of physical capital and income through investment, FDI is a conduit for technology diffusion. Through FDI, countries have access to advanced technology, which increases the rate of technological progress and therefore future income. FDI also increases access to management and increases efficiency gains. The literature also identifies positive spillovers or externalities from FDI as native workers employed by the investing Multi-National Corporations (MNC's) can apply newly learned skills and knowledge acquired on the job, to a new job with a local employer. FDI can also contribute to income through capital deepening by introducing new varieties of capital or intermediary goods and thereby increasing income. (Borensztein et al., 1998; de Mello, 1997)

As in the case for trade and migration, there is evidence that FDI is endogenous to growth (Li and Liu, 2005). Larger markets attract more FDI. At the same time FDI increases market size and economic growth, which attract additional FDI.

So while many authors note the need for instrumental variable analysis, Borensztein et al. (1998) note "that there are no ideal instrumental variables available"[p.33]. And although the gravity model has been used to establish determinants of FDI, there has not been a study using a FR type instrumental variable to estimate the effect of FDI on income.

Investigations into the determinants of FDI have found that FDI flows are driven by similar determinants as trade flows. Blonigen and Piger (2014) identifies the following traditional gravity determinants that consistently explain FDI: real GDP of host and partner country, bilateral distance, common language and colonial relationship. Portes and Rey (2005) find evidence that geography plays an important part in determining international asset flows. As a result, FDI can be considered another channel through which geography affects income. It is prudent therefore to include FDI as part of the set of controls when estimating the effect of trade openness on income using the FR instrument.

In sum, the literature finds evidence that openness to globalization, either trade, migration or FDI, does contribute to higher levels of income. In combination with the evidence that, like trade, migration and FDI can be explained using geographic determinants, allows us to employ the FR instrumentation strategy to generate instruments for each of these determinants of income.

4.3 Methodology

4.3.1 Expanding the simple income regression

I expand the income regression used by FR and others to include migration share, MSH_i, and FDI share, $FDIsh_i$ so that the specification of interest becomes:

$$\ln y_{i,t} = \beta_0 + \beta_1 TSH_{i,t} + \beta_2 MSH_{i,t} + \beta_1 FDIsh_{i,t} + \xi' \mathbf{X}_{i,t} + \gamma_t + \epsilon_{i,t} \tag{4.1}$$

where y_i, t is per capita income at time t, TSH_i is country i's trade share. Because a country's trade openness is endogenous to income, I use the FR methodology to generate an instrumental variable for trade openness based on geography. For the exclusion restriction to be met I include vector $\mathbf{X}_i$, a set of covariates to control for other channels through which geography affects per capita income. The time dummy is included to capture any common trends that affect all countries in the sample. In addition, I present results of estimating a version of equation (4.1) that includes country fixed effects in place of the vector $\mathbf{X}_i$.

Given that both migration and FDI are endogenous to income (Mayda, 2010; Li and Liu, 2005), I apply the FR instrumentation strategy to all three endogenous regressors in (4.1).

4.3.2 Instrumentation strategy using Frankel and Romer(1999)

Before I estimate equation (4.1), I generate instrumental variables for real trade share, migration share and FDI share using the FR instrumentation strategy.

The first step in generating the instrumental variable based on FR is estimating the following specification for each and every time period, t:

$$\begin{aligned} \ln x_{ij,t} = {} & \alpha_{0,t} + \alpha_{1,t} \ln D_{ij} + \alpha_{2,t} \ln N_{i,t} + \alpha_{3,t} \ln N_{j,t} + \alpha_{4,t} \ln A_i + \alpha_{5,t} \ln A_j + \alpha_{6,t}(LL_i + LL_j) \\ & + \alpha_{7,t} B_{ij} + \alpha_{8,t} OffLang_{ij} + \alpha_{9,t} Lang_{ij} + \alpha_{12,t} Colony_{ij} + \alpha_{11,t} T_{ij} \\ & + \text{ interaction terms } + \epsilon_{ij,t} \end{aligned} \tag{4.2}$$

where x_{ij} is either bilateral trade, migration or FDI share between country i and its partner

j; D_{ij} is bilateral distance between the two countries in the pair; N and A are each country's population and area; LL for each country is a dummy variable equal to one if that country is landlocked, i.e. has no coast; and B_{ij} is a dummy taking on the value of 1 if i and j share a common border. As is usual in the literature, we have restricted the coefficient for Landlocked to be equal for both i and j.

Following OP, I include additional explanatory variables that have been found to affect bilateral trade, migration and FDI. The first are two dummy variables that portray to what extend both countries share a common (official) language, $OffLang_{ij}$, and a spoken common language, $Lang_{ij}$. Common language has been found to reduce transaction costs in trade as well as FDI and the costs of assimilation for migrants (Melitz and Toubal, 2014; Adserà and Pytliková, 2015; Blonigen and Piger, 2014; Portes and Rey, 2005) encouraging more trade, migration and FDI between countries.

The other explanatory variables are $Colony_{ij}$ a dummy equal to 1 if there is or was a colonial relationship between country i and country j (Head et al., 2010; Blonigen and Piger, 2014)), and T_{ij} is the time difference between two countries. (Portes and Rey, 2005)

I also include the interaction terms of border with all other covariates to account for the fact that there is more trade, migration and FDI between neighbouring countries than between a similar country pair that do not share a border.

All of the covariates in the bilateral equation (4.2), except population, are time-invariant. Population will not provide enough variation over time, so I estimate equation (4.2) for each and every time period. This allows me to generate a time-varying instrumental variable to use in the panel setting because the estimated coefficients for each covariates will vary over time.[3]

The bilateral trade equation is estimated separately for each of these flows for each year in the sample. Subsequently the estimated coefficients are used to predict the bilateral shares for each country pair ij in the sample, irrespective of whether there is actual trade, migration or FDI between the two countries. The final step in generating the instrumental variable, X_i, all

[3] In Appendix 4F I generate a variation on this generated instrumental variable by following Feyrer (2009b) and estimating across the panel using two measures of distance as opposed to 1. This does not alter the results of the income regressions on each of these variables.

the predicted bilateral shares, x_{ij} are summed across all possible partners:

$$\widehat{X}_{i,t} = \sum_{j} e^{\widehat{\mathbf{b'}}_{\mathbf{x,t}}\mathbf{C_{ij,t}}} \tag{4.3}$$

where $\widehat{\mathbf{b_{x,t}}}$ is the set of estimated coefficients for the share at time t and $\mathbf{C_{ij,t}}$ is the vector of covariates in equation (4.2).[4]

By predicting across all possible partners j in the sample we avoid generating an instrument that is capturing the number of partners and therefore endogenous to income (see Chapter 3). The number of partners is also kept constant over time for the same reason, to avoid capturing endogenous variation. As countries become richer over time, they trade more and with more partners.

As in OP I assume that the sensitivity of trade, migration and FDI to each of the geographic covariates in equation (4.2) is different. In other words, the set of estimated coefficients when bilateral trade share is the dependent variable will vary enough from the set of estimated coefficients when bilateral migration share is the dependent variable as well as the set of estimated coefficients when bilateral FDI share is the dependent variable. This allows me to generate the FR instrument for trade, migration and FDI separately.

In this way I have a distinct time-varying instrumental variable for each of my endogenous regressors in the structural equation.

4.4 Data

The country sample is limited to the OECD members for several reasons. First and foremost, OECD members have the most extensive data on bilateral trade, bilateral migration stocks and FDI flows, which is necessary to construct the FR instrument for each of these endogenous determinants of income. Secondly, the data reported by OECD member countries is more complete and of higher quality than the data reported for developing nations.

The data set covers the period 1993 to 2012. Limited data availability of bilateral migration and bilateral FDI data is the reason that the analysis is restricted to this period.

[4]Because population is time varying, I have to denote vector $\mathbf{C_{ij}}$ as time-varying.

Country data set The data set covers 39 countries, 35 OECD members and 4 non-members that feature as reporter countries in the OECD databases for bilateral migration and bilateral FDI flows.

The measure of country income used is the Expenditure-side real GDP from the Penn World Table v.9.0 (henceforth PWT) at chained PPPs, making comparisons across countries over time possible. This measure of income reflects the standard of living as opposed to the output-capacity. We divide each country's total income by population to construct the measure of per capita real GDP.

Other variables sourced from PWT are population data, real export and real import shares.[5] Finally, PWT is the source for nominal GDP from the national accounts in current national prices and the US $ exchange rate to convert the nominal GDP into US $. Nominal GDP in US$ is used to construct FDI share; see below.

The source of data for the stock of migrants by country of birth in each country is the World Development Indicators . Following the literature the stock of migrants by country of birth is used. Data on the stock of migrants is more readily available than actual annual inflows. Giving preference to a measure that defines a migrant by country of birth as opposed to nationality limits the risk that the measure is an underestimate as it also captures those migrants that become naturalized citizens of their country of residence. The share of migrants is constructed by dividing the stock of migrants by population by each country's population.

The data on total net FDI inflow into each country is the UNCTAD World Investment Report. Net FDI inflow measures foreigners' (i.e. non-residents) investment net disinvestment into each country. Ideally one would like to use gross inflows as this more adequately reflects the volume of capital, which is actually entering and being invested in the country (Borensztein et al., 1998). Net inflows understate the level of investment coming into the country and thus its openness to FDI. However, all comprehensive international data sources only report the net figure. Another drawback to using net inflow is the existence of negative values in cases where annual disinvestment exceeds investment. To maximize the number of observations I use the absolute values of flows as I am investigating the openness of each country to FDI.

[5] PWT provides a series for the shares where the nominal value of exports and imports is adjusted for that country's relative price level of exports and imports, respectively. At the same time the country's GDP (the denominator) is adjusted for the price level of GDP as suggested by Alcalá and Ciccone (2004).

It concerns less than 5% of the observations in the data set. The FDI share relative to GDP is constructed by dividing the total inflow by nominal GDP in US $ sourced from the PWT National Accounts.

The data set is completed with range of different additional controls that enable me to incorporate the Rodriguez and Rodrik (2001) critique of the FR instrument, namely that one needs to control for geographic determinants of income other than trade and migration. Geographic area, as a control for country size, is sourced from CEPII *GeoDist* . To this I add data series collected and made available by Ortega and Peri (2014). These cover a range of factors including regional dummies (for South-East Asia and Latin America[6]), geography, climate, diseases and resources as well as institutional factors such as the origin of the legal framework (French or British).

Bilateral data set The bilateral data set covers the 39 reporters with 183 partner countries in the case of trade and 192 partner countries in the case of migration and 202 for FDI.

Data on bilateral exports and imports are sourced from the Direction of Trade Statistics. . Following the literature I take the stock of migrants, born elsewhere, as the measure of migration and source this measure from the OECD International Migration data base. . Bilateral FDI inflows are sourced from the OECD International Direct Investment Statistics. . As is the case for the country data set, the bilateral FDI reports the net inflow of investment into country i by residents in country j, i.e. investment net disinvestment. As before, I take the absolute values of the flows.

Bilateral trade share and bilateral FDI share are calculated by dividing the bilateral flow by the receiving country's GDP. For bilateral real trade, the sum of bilateral exports and imports are in real terms as is the denominator, GDP. For bilateral FDI share, the volume of bilateral FDI inflow in nominal terms is divided by nominal GDP. Bilateral migration share is the quotient of migrant stock in country i born in j divided by the total population of country i, the receiving country.

Following the literature, data on geographic characteristics like area, common border and landlocked dummies are sourced from the CEPII *GeoDist* data base.

[6]The commonly used set of regional dummies includes a dummy equal to 1 for Sub-Saharan African countries; these are not part of the sample and therefore the dummy is dropped.

The data set is completed by using the population data from PWT v9.0 supplemented with population data from the World Development Indicators(WDI) in cases where PWT does not report data for the partner country.[7]

More information on the data can be found in Appendix 4A.

4.5 Results

4.5.1 The generated instruments

Bilateral equation

I estimate the bilateral equation by OLS with and without country fixed effects and Poisson Pseudo-maximum likelihood method (hence, PPML) using bilateral real trade share, bilateral migration share and bilateral FDI share as dependent variables.

Table 4.1 reports the average coefficient across the 20 year panel as well as the number of times that the coefficient is found to be significant, reported in square parentheses. For those coefficient which are significant most of the time, the sign is as expected. The estimated coefficients for bilateral distance and landlocked countries are often significant and negative as expected. Common (Official) Language when frequently significant is positive which corroborates the evidence cited above that sharing a common language decreases the cost of trade, migration and investment and hence leads to a higher bilateral trade share, migration share and FDI share.

For completeness, figures showing the actual size and development of estimates over time for the OLS estimation without fixed effects for each of the three instruments can be found in Appendix 4B.

Comparing the instruments

I use the estimated coefficients to generate four different versions of the instrument for each year in the panel. The first two are denoted by OLS and PPML and denote the instrument using the estimates generated when estimating the bilateral trade equation by OLS without fixed

[7]PWT uses the WDI as the source of its population data.

Table 4.1. Average estimates of regressing the gravity equation for each cross-section

Estimation:	OLS	FE	PPML	OLS	FE	PPML	OLS	FE	PPML
Dep. variable	Bilateral real trade share:			Bilateral migration share:			Bilateral FDI share:		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\ln Distance_{ij}$	-2.411	-1.478	-1.870	-1.479	-0.862	-1.129	-1.783	-1.032	-2.424
	(0.263)	(0.082)	(0.047)	(0.156)	(0.286)	(0.067)	(0.251)	(0.232)	(0.750)
	[20]	[20]	[20]	[20]	[20]	[20]	[20]	[19]	[19]
$\ln Pop_i$	0.023		-0.260	-0.391		-0.347	-0.877		-0.465
	(0.016)		(0.024)	(0.247)		(0.046)	(0.092)		(0.180)
	[1]		[20]	[20]		[20]	[20]		[17]
$\ln Pop_j$	0.918		0.777	0.803		0.626	0.428		0.696
	(0.024)		(0.014)	(0.033)		(0.076)	(0.075)		(0.323)
	[20]		[20]	[20]		[20]	[20]		[18]
$\ln Area_i$	-0.188		0.038	0.301		0.190	0.281		-0.547
	(0.022)		(0.013)	(0.157)		(0.053)	(0.114)		(0.376)
	[20]		[0]	[19]		[4]	[17]		[14]
$\ln Area_j$	-0.105		-0.113	-0.054		-0.106	-0.215		-0.155
	(0.024)		(0.031)	(0.033)		(0.079)	(0.065)		(0.213)
	[20]		[17]	[8]		[9]	[19]		[3]
$LL_i + LL_j$	-1.130	-1.144	-0.661	-0.739	0.110	-0.040	-0.118	-1.073	-0.062
	(0.043)	(1.559)	(0.182)	(0.190)	(2.506)	(0.087)	(0.510)	(2.138)	(0.263)
	[20]	[17]	[20]	[20]	[10]	[0]	[8]	[11]	[1]
Border$_{ij}$	-5.151	-1.892	-8.744	1.512	-0.098	-0.744	-22.087	-1.340	-25.775
	(1.356)	(0.653)	(2.009)	(2.639)	(2.001)	(2.004)	(7.701)	(3.324)	(8.602)
	[14]	[0]	[20]	[0]	[0]	[0]	[19]	[2]	[20]
Common Official	-0.048	0.412	0.114	0.898	0.790	0.189	0.403	0.353	-0.200
Language$_{ij}$	(0.098)	(0.064)	(0.046)	(0.410)	(0.200)	(0.227)	(0.416)	(0.371)	(1.008)
	[0]	[20]	[0]	[16]	[17]	[0]	[2]	[4]	[1]
Common	0.987	0.178	0.682	1.255	0.276	1.113	0.730	0.391	1.045
Language$_{ij}$	(0.082)	(0.057)	(0.113)	(0.458)	(0.103)	(0.189)	(0.347)	(0.320)	(0.681)
	[20]	[7]	[20]	[19]	[6]	[19]	[7]	[7]	[11
Time	0.269	0.000	0.238	0.101	-0.061	0.056	0.308	0.012	0.547
Difference$_{ij}$	(0.038)	(0.013)	(0.007)	(0.044)	(0.103)	(0.025)	(0.091)	(0.064)	(0.221)
	[20]	[2]	[20]	[17]	[19]	[7]	[20]	[3]	[19]
Colony$_{ij}$	1.591	1.132	1.388	0.255	1.604	1.927	1.027	0.796	2.836
	(0.366)	(0.094)	(0.406)	(1.271)	(0.218)	(0.759)	(1.013)	(0.296)	(1.214)
	[19]	[20]	[20]	[8]	[20]	[11]	[7]	[15]	[16]
Hegemon$_i$	-0.759		-1.547	1.325		-0.676	-1.106		-2.097
	(0.204)		(0.328)	(1.326)		(0.938)	(1.015)		(1.477)
	[0]		[20]	[18]		[4]	[6]		[13]
Hegemon$_j$	0.297		-0.992	0.623		-0.293	1.480		-2.831
	(0.179)		(0.274)	(1.348)		(0.538)	(1.155)		(1.754)
	[0]		[20]	[6]		[0]	[6]		[15]
R^2	0.540	0.831		0.554	0.835		0.317	0.780	
	(0.024)	(0.014)		(0.026)	(0.026)		(0.047)	(0.027)	
N	6581.30	6615.05	7800.00	2384.60	2393.95	7800.00	1143.75	1144.60	7800.00
	(186.80)	(188.67)	(0.00)	(1049.91)	(1054.63)	(0.00)	(332.44)	(332.70)	(0.00)
RMSE	2.157	1.327		1.895	1.221		2.763	1.699	
	(0.028)	(0.025)		(0.126)	(0.032)		(0.298)	(0.193)	

Notes: The table reports the average of the 20 coefficients estimated for each cross section of the data. The standard deviation of that average is reported in (round parentheses). The number in [square brackets] is the number of times (out of 20) that the estimated coefficient is significant at the 5% significance level. Column heading 'OLS' indicates that estimates for the bilateral equation without country fixed effects. Columns with 'FE' report estimates from the bilateral equation with country fixed effects estimated using OLS. While 'PPML' denotes the estimates using using Poisson Pseudo-Maximum Likelihood Method. Table B1 in the Appendix reports the results for the border interaction terms, completing the Table.

Table 4.2. Correlation coefficients of generated instruments and actual shares

	(1) RTSH$_i$	(1A) $\widehat{RTSH}_i^{OLS}$	$\widehat{RTSH}_i^{FE1}$	$\widehat{RTSH}_i^{FE2}$	(1B) $\widehat{RTSH}_i^{PPML}$	(2) MSH$_i$	(2A) $\widehat{MSH}_i^{OLS}$	$\widehat{MSH}_i^{FE1}$	$\widehat{MSH}_i^{FE2}$	(2B) $\widehat{MSH}_i^{PPML}$	(3) FDIsh$_i$	(3A) $\widehat{FDIsh}_i^{OLS}$	(3B) $\widehat{FDIsh}_i^{FE1}$	$\widehat{FDIsh}_i^{FE2}$	(3C) $\widehat{FDIsh}_i^{PPML}$
RTSH$_i$	1														
$\widehat{RTSH}_i^{OLS}$	0.721***	1													
	(0.000)														
$\widehat{RTSH}_i^{FE1}$	0.556***	0.581***	1												
	(0.000)	(0.000)													
$\widehat{RTSH}_i^{FE2}$	0.150***	0.0889**	0.0128	1											
	(0.000)	(0.014)	(0.724)												
$\widehat{RTSH}_i^{PPML}$	0.795***	0.880***	0.344***	0.115***	1										
	(0.000)	(0.000)	(0.000)	(0.001)											
MSH$_i$	0.243***	0.333***	0.0204	0.00197	0.369***	1									
	(0.000)	(0.000)	(0.574)	(0.957)	(0.000)										
$\widehat{MSH}_i^{OLS}$	0.0737**	0.132***	-0.0540	-0.0224	0.135***	0.298***	1								
	(0.042)	(0.000)	(0.136)	(0.537)	(0.000)	(0.000)									
$\widehat{MSH}_i^{FE1}$	-0.190***	-0.0817**	-0.159***	-0.0330	-0.0600*	0.102***	0.168***	1							
	(0.000)	(0.024)	(0.000)	(0.363)	(0.098)	(0.005)	(0.000)								
$\widehat{MSH}_i^{FE2}$	0.0524	0.0378	-0.000380	-0.00898	0.0356	0.0102	-0.0228	-0.0312	1						
	(0.148)	(0.297)	(0.992)	(0.804)	(0.326)	(0.778)	(0.530)	(0.390)							
$\widehat{MSH}_i^{PPML}$	0.598***	0.701***	0.122***	0.0822**	0.785***	0.481***	0.276***	-0.153***	0.0405	1					
	(0.000)	(0.000)	(0.001)	(0.023)	(0.000)	(0.000)	(0.000)	(0.000)	(0.264)						
FDIsh$_i$	0.283***	0.423***	0.0858**	-0.00144	0.400***	0.210***	0.128***	-0.0419	0.0112	0.417***	1				
	(0.000)	(0.000)	(0.018)	(0.968)	(0.000)	(0.000)	(0.000)	(0.248)	(0.757)	(0.000)					
$\widehat{FDIsh}_i^{OLS}$	0.401***	0.586***	0.0956***	0.0405	0.579***	0.333***	0.178***	-0.0163	0.00950	0.556***	0.471***	1			
	(0.000)	(0.000)	(0.008)	(0.264)	(0.000)	(0.000)	(0.000)	(0.653)	(0.793)	(0.000)	(0.000)				
$\widehat{FDIsh}_i^{FE1}$	0.251***	0.534***	0.101***	0.0709*	0.447***	0.268***	0.144***	0.00463	0.00685	0.422***	0.483***	0.661***	1		
	(0.000)	(0.000)	(0.005)	(0.051)	(0.000)	(0.000)	(0.000)	(0.898)	(0.850)	(0.000)	(0.000)	(0.000)			
$\widehat{FDIsh}_i^{FE2}$	-0.0634*	-0.0486	-0.0434	-0.00915	-0.0425	-0.0122	0.0244	0.0335	0.0269	-0.0647*	-0.0115	-0.0110	0.518***	1	
	(0.080)	(0.180)	(0.231)	(0.801)	(0.241)	(0.737)	(0.501)	(0.355)	(0.458)	(0.074)	(0.751)	(0.763)	(0.000)		
$\widehat{FDIsh}_i^{PPML}$	0.334***	0.640***	0.128***	0.0327	0.553***	0.342***	0.159***	-0.00266	0.0307	0.559***	0.754***	0.765***	0.726***	-0.0145	1
	(0.000)	(0.000)	(0.000)	(0.368)	(0.000)	(0.000)	(0.000)	(0.942)	(0.397)	(0.000)	(0.000)	(0.000)	(0.000)	(0.690)	
N	762														

Notes: Standard errors reported in parentheses. Superscript OLS indicates that the instrument is generated using OLS to estimate the bilateral equation without country fixed effects. FE indicates that the instrument is generated using estimates from a bilateral equation with country fixed effects estimated using OLS; FE1 indicates that country fixed effects are included in the prediction while FE2 that country fixed effects are excluded. The superscript PPML indicates that the bilateral equation is estimated using using Poisson Pseudo-Maximum Likelihood Method. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

effects and PPML, respectively. The final two versions are generated using the estimates from OLS with country fixed effects in the bilateral equation. The first version (denoted by FE1) includes the estimates for the country fixed effects when predicting, while the second, denoted by the superscript FE2, excludes these coefficients for country fixed effects. The motivation for excluding country fixed effects is that these are a catch all covariates capturing time-invariant country characteristics. Some of these, for instance infrastructure, are endogenous to income and will invalidate the instrument if they are included so should be excluded unless one can control for these in the income regression. As I am using panel data, I am able to include country fixed effects in the income regression which allows me to control for the country characteristics included in the generated instruments that are endogenous to income.

Table 4.2 reports the correlation coefficients between the endogenous regressors, real trade share, migration share, FDI share and each generated instrument. First, in column 1 of Table 4.2 that, as expected, there is a positive correlation between real trade share and migration share as well as between real trade share and FDI-share, and migration and FDI-share (see column 2). The reported correlation coefficients across the sample are 0.243, 0.283 and 0.210, respectively.

Second, columns 1, 2 and 3 show that the instruments denoted by OLS, FE1, and PPML are positively and significantly correlated to their corresponding endogenous regressor. The exception is the second of the fixed effects instrument, FE2 that excludes country fixed effects when predicting, FE2. The correlation coefficient with the corresponding regressors is much lower than that of its counterpart FE1. In all cases except for real trade the correlation coefficient for the former is actually not significantly different from zero (see columns 2 and 3). I therefore discard the FE2-instruments in the further analysis.

I now turn to select a set of instruments to use in the panel analysis of the income regression. For each of the endogenous regressor I am looking for an instrument that is most correlated with the enodogenous regressor but not (highly) correlated with the other two endogenous regressors and also not correlated to each other.

Of all the versions of the instruments the version generated by estimating the bilateral equation the PPML version, has the highest correlation coefficient with the corresponding endogenous regressor - well above 0.75 for real trade share in column 1 and FDI share in column 3, while 0.48 for migration share in column 2. However, each of these instruments is also highly correlated with the other, non-corresponding endogenous regressors. A case in point is the correlation coefficient between the instrument, $\widehat{MSH}_i^{PPML}$, and real trade share, $RTSH_i$, of 0.60. This is higher than the correlation between the predicted migration share and its corresponding endogenous regressor, MSH_i, of 0.48. Also as can be seen in column 1B and 2B the correlation between the individual instruments, so between $\widehat{RTSH}_i^{PPML}$, $\widehat{MSH}_i^{PPML}$ and $F\widehat{DI}sh_i^{PPML}$ is quite high ranging from 0.55 to 0.79 and therefore comparable in size to the correlation between each instrument and its corresponding endogenous regressor. I expect that using this set will as instruments in the income regression analysis, will not allow me to identify the individual effects of each of the variables of interest on income, real trade share, migration share and FDI share.

The instrument set generated using the OLS estimation without fixed effects, with superscript OLS, is the preferred set of instruments. The correlation coefficients between the instrument and its corresponding regressor is high with 0.72 for real trade share in column 1, 0.30 for migration share in column 2 and 0.47 for FDI share in column 3. Although each instrument is positively correlated with the other endogenous regressors as witnessed in columns 1A and 2A, the correlation coefficients are lower than the ones for the PPML counterparts, ranging from 0.07 between the actual real trade share and predicted migration share, to 0.42 between the actual FDI share and predicted real trade share. At the same time each instrument is not highly correlated with the other two instrumental variables as indicated by the correlation coefficient of 0.132 between predicted real trade share and migration share (column 1A), and 0.178 between predicted migration share and predicted FDI share (column 2A). The partial correlations show similar patterns to those of the correlation coefficients.

Consequently, I opt to use the versions generated by using the OLS estimates, $\widehat{RTSH}_i^{OLS}$, $\widehat{MSH}_i^{OLS}$ and $F\widehat{DI}sh_i^{OLS}$. Before proceeding to the estimation results of the income regression, I must note that the correlation between predicted real trade share and predicted FDI share is high at 0.59, higher than the reported correlation coefficient of 0.47 between the predicted FDI share and its endogenous regressor in column 3. This is a concern for the ability of the instrument for FDI share to distinctly identify the effect of the endogenous regressor on income. Alternative versions, FE1 or PPML do not solve the problem as the former only marginally lowers the correlation coefficient between predicted FDI share and predicted real trade share while the instrument generated using PPML estimates increases the correlation coefficient between predicted FDI share and predicted real trade share to 0.64.[8] I address this issue of identification when discussing the results of the IV-analysis.

4.5.2 A preview of panel results: long differences using OLS

Before I present and discuss the results of the panel analysis, I present an initial investigation of the relationship of interest in equation (4.1) using long differences. This allows for an initial inventory of how the estimated coefficient for trade changes as migration and FDI are added to the income equation.

Following Feyrer (2009b), I use the change in income per capita over the entire period on the change in trade, controlling for the changes in migration as well as FDI over the same period.

$$\Delta \ln y_i = \alpha + \Delta \ln T_i + \Delta \ln M_i + \Delta \ln FDI_i + \epsilon_i \tag{4.4}$$

where y_i is income per capita, T_i is the volume of trade, M_i is the migration stock and FDI_i the volume of Foreign Direct Investment for country i. By taking differences I do not have to separately control for across country differences, including country size, so I do not include a specific country fixed effect. Taking differences also allows me to use the volume of trade, actual migration stock and volume of FDI instead of their shares. Any time trends are captured by the constant.

Table 4.3 column 4 reports the result of estimating equation (4.4); the remaining columns report results of variations of (4.4). Columns 1 through 4 show us that the coefficient for trade is positive as expected and significant, despite adding different controls for log changes in migration and FDI. The only change is to the size of the coefficient, which is smaller when controlled for migration (column 2) and unchanged when FDI inflow is controlled for (column 3).

The coefficient for trade in column 1 is smaller than the comparable coefficient found by Feyrer (2009b). These can be attributed to the differences in the data sets; this sample only analyses OECD countries over the period 1993-2012 whereas Feyrer's data set covers a more

[8]For completeness it must be noted that the version of the instrument generated using PPML estimates is more highly correlated with the endogenous regressor, FDI share, than with the other instrument $\widehat{RTSH}_i^{OLS}$.

Table 4.3. Effect of real trade, migration and FDI growth on per capita income growth, 1993-2012

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta \ln \textit{Real trade}_i$	0.431***	0.391***	0.434***	0.391***			
	(0.082)	(0.079)	(0.090)	(0.085)			
$\Delta \ln \textit{Migration}_i$		-0.093		-0.093	-0.163**		-0.160**
		(0.058)		(0.059)	(0.073)		(0.074)
$\Delta \ln \textit{FDI}_i$			-0.002	0.000		0.032	0.030
			(0.015)	(0.011)		(0.027)	(0.020)
Constant	0.011	0.105	0.011	0.105	0.637***	0.497***	0.574***
	(0.094)	(0.100)	(0.095)	(0.102)	(0.051)	(0.049)	(0.058)
N	36	36	36	36	36	36	36
R^2	0.464	0.512	0.465	0.512	0.159	0.052	0.205

Notes: Dependent variable is the change in the log of per capita Expenditure-side Real GDP (at chained PPP's) over the period 1993-2012. Heteroskedastic robust errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Belgium, Luxembourg and Switzerland are excluded from the sample because of data availability.

diverse set of 76 countries and the period 1960-1995. The earlier period (1960-1995) saw larger growth rates of trade than the period that is covered by my data set. A final difference with Feyrer is that I am using real trade, a measure where nominal trade has been corrected for the price levels of exports and price levels of imports as constructed by Feenstra et al. (2015). In comparison across my sample real trade has a lower sample average and standard deviation than nominal trade. This may also partially explain the lower estimate that I report in Table 4.3.

Surprisingly the coefficient on migration is negative which contradicts results by OP who find a positive coefficient for migration in their cross-sectional analysis. It is only significant when used by itself to explain the cross country variation in income (see column 5), and only explains 16% of the variation in income. Furthermore, the size of the coefficients is small; smaller than the estimates in the study by OP and Andersen and Dalgaard (2011). On the basis of these results migration does not seem an important determinant for income.

The coefficient for FDI growth is not significantly different from zero in any specification even when used by itself in column 7 of Table 4.3 only 5% of the variation in income growth is explained by FDI growth.

The results are robust to the exclusion of countries that can be considered outliers. It is also robust to the choice of start and end date of the period over which the log changes are calculated. See Appendix 4C.

In conclusion, controlling for FDI growth has no effect on the estimated coefficient for trade growth. Controlling for migration, however, does lower the estimated coefficient. Furthermore, the estimate for trade is significant and positive in all specification. Meanwhile the estimate for migration is negative and only significant if migration is used as a sole determinant or together with FDI which is insignificant in all specifications.

I now move on to a panel analysis of the data which allows for more sophisticated analysis using more observations.

4.5.3 Panel results

To test the hypothesis that one must control for other globalization flows outside of real trade when estimating real trade openness' effect on income, I start with the simple regression of income on real trade share (reported in column 1 of each table) and first add migration share (column 2) and FDI-share (column 3) separately before adding both migration and FDI share simultaneously to the regression (column 4). Subsequently, I also test the effect of migration share and FDI-share on income individually as well simultaneously. These results are reported in columns 5, 7, and 6, respectively. Throughout this section, all tables will report results in the same sequence.

Using OLS Table 4.4 reports results from a simple OLS estimation of the income regression. Initially, I only control for country size using the log of population and the log of area in Panel A and then add other geographic controls in Panel B. Panel C reports the estimation results from including country fixed effects in lieu of country size and the geographic controls. The results in Panel C make full use of the information contained in the data. These are also the most comparable to the data reported in Table 4.3. The results reported in Panel A and B allow me to make a comparison with the results reported by FR in Panel A and OP, respectively. Because both studies were cross-sectional, they could not control for country fixed effects.

The estimate for real trade openness's effect on income is slightly smaller but comparable to that found in the previous literature. Once I control for migration openness, the size of the coefficient decreases but is still significant at the 1% significance level. The difference between

Table 4.4. OLS estimates of the Income regression, 1993-2012

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Panel A: Simple Income regression			
Real TSH$_i$	0.630***	0.574***	0.621***	0.576***			
	(0.057)	(0.049)	(0.057)	(0.049)			
MSH$_i$		2.479***		2.486***	2.688***	2.659***	
		(0.180)		(0.181)	(0.235)	(0.237)	
FDI-share$_i$			0.210	-0.040		0.152*	0.437***
			(0.148)	(0.165)		(0.085)	(0.118)
N	762	762	762	762	762	762	762
R^2	0.289	0.429	0.291	0.429	0.307	0.308	0.149
Country FE	No	No	No	No	No	No	No
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geo. controls	No	No	No	No	No	No	No
RMSE	0.441	0.396	0.441	0.396	0.436	0.436	0.483
				Panel B: Including Additional Geographic Controls			
Real TSH$_i$	0.380***	0.446***	0.377***	0.443***			
	(0.063)	(0.060)	(0.063)	(0.060)			
MSH$_i$		2.049***		2.012***	1.745***	1.701***	
		(0.211)		(0.210)	(0.241)	(0.241)	
FDI-sh$_i$			0.269***	0.163***		0.202***	0.289***
			(0.069)	(0.054)		(0.061)	(0.077)
N	662	662	662	662	662	662	662
R^2	0.713	0.759	0.717	0.760	0.713	0.715	0.683
Country FE	No	No	No	No	No	No	No
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geo. controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RMSE	0.267	0.245	0.266	0.245	0.267	0.267	0.281
				Panel C: Using Country Fixed Effects			
Real TSH$_i$	0.162***	0.043	0.163***	0.044			
	(0.029)	(0.030)	(0.029)	(0.031)			
MSH$_i$		-2.366***		-2.363***	-2.555***	-2.557***	
		(0.401)		(0.402)	(0.375)	(0.374)	
FDI-share$_i$			0.030	0.024		0.020	0.012
			(0.022)	(0.028)		(0.028)	(0.021)
N	762	762	762	762	762	762	762
R^2	0.962	0.965	0.962	0.965	0.965	0.965	0.960
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RMSE	0.105	0.100	0.105	0.100	0.100	0.100	0.108

Notes: Robust standard errors in parentheses except in Panel B where standard errors are clustered by country. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable in all panels is Expenditure-side real GDP per capita (at chained PPP's) from PWT v.9.0. Specifications reported in panels A and B columns 1 through 7 include $\ln Population_i$ and $\ln Area_i$ as well as constant but these are not reported. Geographic controls are Distance to the Equator, Percentage of land in the tropics, distance of the i's centroid to the coast, dummy equal to 1 if i is landlocked, dummy equal to 1 if i is in Latin-America, a dummy equal to 1 if i is either Australia, Canada, New Zealand or the United States, dummy equal to 1 if i is or was a British colony, climate indexes of average temperature and humidity as well as soil quality, dummy equal to 1 if there is an incidence of yellow fever, and a measure of oil reserves. Constant is included in all regressions but not reported.

the coefficient for real trade share reported in columns 1 and 2 is roughly 1 standard error. At the same time the coefficient for migration share is positive and much larger than that of real trade, which seems to support the argument by OP that migration openness is more important than real trade. I will revisit the issue below after the discussion of the IV results reported below.

Controlling for FDI share as is done in Panel A column 3, however, does not affect the size of the coefficient for real trade openness reported in column 1. This is not surprising given that the coefficient for FDI share is not significantly different from zero and that adding FDI share to the regression does not increase how much of the variation in income is explained by the determinants, as evidenced by the reported R^2 and *RMSE* in columns 1, 2 and 5 compared to those in 3, 4 and 6, respectively. FDI share also does not have a large effect on the estimated coefficients for real trade openness and migration share in column 4. Again, compared to column 2 the estimated coefficient for FDI share in column 4 is small and not significantly different from zero, so I am not as concerned with the negative sign which different from that in column 3 even though the switch in the sign of the coefficient could be an indication that FDI share is not well identified within the model. However, once I control for other geographic factors affecting income the results in columns 3 and 4 of Panel B indicate that FDI share is positive throughout and contrary to the results in Panel A, significantly different from zero at 1% significance level. Also the results in columns 6 and 7 of both Panels A and B indicate that individually and simultaneously with migration share, FDI share is positive and significantly different from zero.

Comparing Panels A and B, when additional geographic controls are included, coefficients for real trade share and migration share are lower, as expected. Furthermore, a comparison of coefficients reported in columns 1 and 2 shows that the inclusion of the migration share in the income regression with real trade share, affects the size of the coefficient for real trade share; only in this case the estimated coefficient increases by roughly 1 standard error from column 1 to 2 as opposed to panel A where it decreases. As before comparing the coefficient for real trade in columns 1 with 3 and columns 2 with 4 we see that the inclusion of the FDI-share as a control does not affect the size of the estimated coefficient for real trade share. The comparison of estimated coefficients for migration share in columns 2 and 4 as well as a comparison of the coefficients reported in columns 5 and 6 also show no difference in the size of the coefficients. So, the effects of controlling for FDI-share do not affect the results for real trade and migration share although the coefficients for FDI-share are significant and positive for all specifications.

In Panel C real trade share is significant and positive when the sole determinant in the income regression. However, it ceases to be once I control for migration share in column 2, contradicting earlier results in Table 4.3 in the previous section. Panel C does confirm the result with respect to controlling for FDI. Comparing columns 1 with 3 and 2 with 4, the size of and significance of the coefficient for real trade share is unchanged.

In contrast to the earlier results of Panel A and B, the effect of migration openness on income is now negative and significant at the 1% significance level. As the analysis in Panel C is comparable to that conducted in the previous section, the sign on migration is not surprising. Even though I did not directly control for country fixed effects in the previous section, by taking differences I eliminate all time invariant determinants from the regression. The switch in sign as a result of using fixed effects instead of geographic controls, is notable though and an indication that migration is not well identified in the regression analysis.

Finally, FDI is now insignificant in all estimations in Panel C of Table 4.4 corresponding with the results from the previous section. Additional to the earlier observation that controlling for FDI does not effect the estimate for trade share, it also does not affect the estimate for migration as seen in a comparison of columns 2 and 4 as well as columns 5 and 6.

Using 2SLS Tables 4.5 and 4.6 report the results of the 2SLS estimation of the specifications used in the OLS estimation of Panel A and Panel B of Table 4.4, respectively. Table 4.7 reports the results of the 2SLS estimation of the specifications used in Panel C of Table 4.4.

As noted at the start of the section, the sequence of reported specifications across columns is unchanged to the sequence in Table 4.4. Columns 1 through 4 include trade share while the remaining columns report the estimation results using migration individually, both migration and FDI, and FDI individually in columns 5, 6, and 7, respectively. All reported standard errors are not adjusted for the use of generated instruments for each of the endogenous regressors. In this I follow Ortega and Peri (2014) who also do not correct standard errors when using generated instruments for both trade share and migration share. Wooldridge (2002) allows for simply using robust standard errors in the case of using generated instruments. Finally, I note

Table 4.5. IV estimates of the Income regression, 1993-2012

	(1)	(2)		(3)		(4)			(5)	(6)		(7)
Panel A: Second-stage regressions (selected results):												
$RTSH_i$	0.820***	0.050		0.106		-0.262						
	(0.125)	(0.271)		(0.124)		(0.209)						
MSH_i		5.157***				4.650**			5.275***	4.185**		
		(1.713)				(1.979)			(1.110)	(1.666)		
$FDIsh_i$				3.071***		1.665				1.458		3.234***
				(1.151)		(1.016)				(0.942)		(1.189)
N	762	762		762		762			762	762		762
Country FE	No	No		No		No			No	No		No
Time FE	Yes	Yes		Yes		Yes			Yes	Yes		Yes
Geo. controls	No	No		No		No			No	No		No
RMSE	0.439	0.465		0.540		0.520			0.475	0.470		0.557
Panel B: First-stage regressions (selected results):												
	$RTSH_i$	$RTSH_i$	MSH_i	$RTSH_i$	$FDIsh_i$	$RTSH_i$	MSH_i	$FDIsh_i$	MSH_i	MSH_i	$FDIsh_i$	$FDIsh_i$
$\widehat{RTSH}_i$	0.491***	0.496***	0.057***	0.610***	0.058**	0.617***	0.047***	0.052**				
	(0.055)	(0.057)	(0.012)	(0.060)	(0.026)	(0.063)	(0.014)	(0.022)				
$\widehat{MSH}_i$		-0.095	0.332*			-0.139	0.336*	0.104	0.470**	0.414**	0.190	
		(0.133)	(0.173)			(0.129)	(0.175)	(0.144)	(0.193)	(0.183)	(0.176)	
$\widehat{FDIsh}_i$				-0.923***	0.441**	-0.928***	0.072*	0.444**		0.207***	0.592***	0.618**
				(0.218)	(0.182)	(0.219)	(0.042)	(0.184)		(0.048)	(0.227)	(0.246)
F-statistic	78.86	39.75	63.12	56.05	3.358	37.63	54.40	3.173	5.943	29.44	3.763	6.299
Partial R^2	0.274	0.274	0.137	0.299	0.188	0.299	0.139	0.191	0.0844	0.116	0.175	0.167
SW F-stat	78.86	6.396	4.167	48.75	23.18	21.77	4.397	15.08	5.943	5.154	8.026	6.299
	[0.000]	[0.012]	[0.039]	[0.000]	[0.000]	[0.000]	[0.042]	[0.000]	[0.015]	[0.044]	[0.005]	[0.012]
AP F-stat	78.86	161.9	4.281	91.94	33.65	153.9	4.134	25.07	5.943	4.063	17.28	6.299
	[0.000]	[0.000]	[0.042]	[0.000]	[0.000]	[0.000]	[0.036]	[0.000]	[0.015]	[0.024]	[0.000]	[0.012]
Panel C:Reduced form (selected results):												
$\widehat{RTSH}_i$	0.402***	0.317***		0.241***		0.145***						
	(0.031)	(0.039)		(0.046)		(0.054)						
$\widehat{MSH}_i$		1.708***				1.770***			2.479***	2.010***		
		(0.388)				(0.408)			(0.571)	(0.441)		
$\widehat{FDIsh}_i$				1.256***		1.315***				1.729***		1.998***
				(0.323)		(0.332)				(0.307)		(0.335)
R^2	0.210	0.233		0.227		0.251			0.195	0.246		0.212

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable in panel A and C is the log of Real GDP_i; the first row of panel B reports the dependent variable for each first-stage regression. All specifications include $\ln Population_i$ and $\ln Area_i$ and a constant. F-stat is the first stage F-statistic of excluded instruments. SW F-stat refers to the Sanderson and Windmeijer (2016) multivariate F-statistic of excluded instruments, an improved version of the Angrist and Pischke (2009) F-statistic, labeled AP F-stat in this table. The null hypothesis of these tests is that the endogenous regressor is unidentified. The associated p-values of both tests is reported in [square brackets]. In case of only one endogenous regressor both the SW F-stat and AP F-stat are equal to the F-statistic of excluded instruments. Partial R^2 refers to the squared partial correlation corresponding to the SW F-statistic.

that the dependent variable in panels A and C are income per capita while the first row of panel B reports the dependent variable of each of the first-stage regressions.

As was the case for the OLS results when country fixed effects were excluded from the income regression, individually trade share, migration share and FDI-share are a positive determinant of income, as shown by the estimated coefficients in columns 1, 5 and 7, respectively, in Panel A in both tables. For all three the estimated IV-coefficients are larger than their counterparts reported in Panels A and B of Table 4.4. The size of the estimated coefficient for real trade share is lower than that found in the previous literature. The size of the coefficient for migration share is comparable to the one found by OP in their cross-sectional study for the year 2000, although at the lower end of their estimates.

Table 4.6. IV estimates of the Income Regression incl. geographic controls, 1993-2012

	(1)	(2)		(3)		(4)			(5)	(6)		(7)
Panel A: Second-stage regressions (selected results):												
RTSH_i	1.215***	0.621**		0.251		0.222						
	(0.202)	(0.242)		(0.163)		(0.140)						
MSH_i		4.398***				1.741			5.088***	1.913		
		(1.665)				(3.967)			(1.429)	(4.009)		
FDIsh_i				2.612***		2.054				2.104		2.733***
				(0.950)		(1.312)				(1.337)		(1.000)
N	662	662		662		662			662	662		662
Country FE	No	No		No		No			No	No		No
Time FE	Yes	Yes		Yes		Yes			Yes	Yes		Yes
Geo. controls	Yes	Yes		Yes		Yes			Yes	Yes		Yes
RMSE	0.326	0.267		0.357		0.312			0.311	0.328		0.374
Panel B: First-stage regressions (selected results):												
	RTSH_i	RTSH_i	MSH_i	RTSH_i	FDIsh_i	RTSH_i	MSH_i	FDIsh_i	MSH_i	MSH_i	FDIsh_i	FDIsh_i
$\widehat{RTSH}_i$	0.358***	0.376***	0.040***	0.513***	0.075**	0.537***	0.023**	0.066**				
	(0.053)	(0.054)	(0.009)	(0.072)	(0.037)	(0.073)	(0.010)	(0.030)				
$\widehat{MSH}_i$		-0.346**	0.160**			-0.409**	0.166**	0.163	0.223**	0.193**	0.237	
		(0.168)	(0.079)			(0.166)	(0.078)	(0.198)	(0.095)	(0.082)	(0.226)	
$\widehat{FDIsh}_i$				-0.992***	0.365**	-1.011***	0.108***	0.373**		0.162***	0.526**	0.549**
				(0.250)	(0.161)	(0.253)	(0.034)	(0.165)		(0.033)	(0.205)	(0.222)
F-statistic	45.33	25.28	22.20	28.39	3.286	20.78	21.95	2.729	5.470	20.82	3.451	6.113
Partial R^2	0.151	0.155	0.0780	0.197	0.136	0.203	0.0896	0.141	0.0407	0.0820	0.126	0.115
SW F-stat	45.33	6.903	5.054	27.14	12.13	33.02	3.639	4.184	5.470	3.683	4.127	6.113
	[0.000]	[0.009]	[0.025]	[0.000]	[0.001]	[0.000]	[0.109]	[0.035]	[0.020]	[0.055]	[0.066]	[0.014]
AP F-stat	45.33	53.20	7.161	39.39	18.30	48.21	2.577	4.444	5.470	1.995	3.395	6.113
	[0.000]	[0.000]	[0.008]	[0.000]	[0.000]	[0.000]	[0.057]	[0.041]	[0.020]	[0.158]	[0.043]	[0.014]
Panel C: Reduced form (selected results):												
$\widehat{RTSH}_i$	0.435***	0.410***		0.325***		0.294***						
	(0.035)	(0.034)		(0.048)		(0.048)						
$\widehat{MSH}_i$		0.488***				0.533***			1.136***	0.867***		
		(0.163)				(0.168)			(0.255)	(0.175)		
$\widehat{FDIsh}_i$				0.704***		0.730***				1.416***		1.500***
				(0.229)		(0.235)				(0.275)		(0.285)
R^2	0.732	0.734		0.737		0.740			0.691	0.726		0.719

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable in panel A and C is the log of Real GDP_i; the first row of panel B reports the dependent variable for each first-stage regression. All specifications include $\ln Population_i$ and $\ln Area_i$ and a constant. Geo. controls indicate the inclusion of additional set of geographic country characteristics, namely Distance to the Equator, Percentage of land in the tropics, distance of the i's centroid to the coast, dummy equal to 1 if i is landlocked, dummy equal to 1 if i is in Latin-America, a dummy equal to 1 if i is either Australia, Canada, New Zealand or the United States, climate indexes of average temperature and humidity as well as soil quality, dummy equal to 1 if there is an incidence of yellow fever, and a measure of oil reserves. F-stat is the first stage F-statistic of excluded instruments. SW F-stat refers to the Sanderson and Windmeijer (2016) multivariate F-statistic of excluded instruments, an improved version of the Angrist and Pischke (2009) F-statistic, labeled AP F-stat in this table. The null hypothesis of these tests is that the endogenous regressor is unidentified. The associated p-values of both tests is reported in [square brackets]. In case of only one endogenous regressor both the SW F-stat and AP F-stat are equal to the F-statistic of excluded instruments. Partial R^2 refers to the squared partial correlation corresponding to the SW F-statistic.

Regarding instrument strength, an F-statistic of 78,86 reported in Panel B of Table 4.5 shows that the instrument for real trade share is strong an which is confirmed by the high Partial R^2. This is also the case in Table 4.6. The F-statistic for migration share and FDI share reported in columns 5 and 7 of Panel B, however, do not exceed the Staiger and Stock (1997) threshold of 10, indicating that the second-stage results are likely to be inconsistent. Predicted migration share, especially has a low Partial R^2 compared to the same statistic for real trade share and FDI-share in columns 1 and 7 of Panel B.

More importantly for my hypothesis, Table 4.5 Panel A columns 2, 3 and 4 show that once I control for either migration share, FDI-share or both, respectively, that the size of the coefficient for trade share is reduced and actually becomes insignificant except in column 2 of Table 4.6 when controlling for additional channels through which geography can affect income.

In contrast to the OLS analysis, controlling for FDI share will affect the size and significance of the coefficient for trade share. In column 3 FDI share is now significant whereas trade shares ceases to be significant. Once all three determinants are included in the income regression column 4 reports that only the coefficient for migration share is significantly different from zero when controlling for country size in Table 4.5, but not when adding geographic controls in Table 4.6. Trade share and FDI share cease to be significant in both instances.

Regarding the strength of the instrument used for trade share, columns 1, through 4 of Panel B of both Tables report large F-statistic and Partial R^2 for the first-stage regressions where real trade share is the dependent variable in . Also the Sanderson and Windmeijer (2016) conditional F-statistic (henceforth, SW F-statistic) for real trade share is large and significant at least at the 5% significance level throughout. The null hypothesis that the instrument is weak can be rejected in all three specifications.

The evidence that predicted migration share is a strong instrument is weaker. Although the reported first-stage F-statistic is large in column 5, the Partial R^2 is small. Yet, at the same time the SW F-statistic is significant at the 10% significance level.

Finally, there is no evidence to make the case for predicted FDI share. The first-stage F-statistic of excluded instruments for FDI share is very low in columns 3, 4, 6 and 7 of both tables. Furthermore, the reported coefficients on the predicted FDI share in the first-stage regression for the actual real trade share is larger than the coefficient of the predicted trade share in columns 3 and 4. This also applies to the coefficients for the reduced form regressions in columns 3 and 4 of Panel C. This mirrors the high correlation coefficient between the two instrumental variables as well as with each instrumental variable and actual real trade share, I identified in Table 4.2. Finally, when comparing the first-stage F-statistics across the two tables, one notices that these are lower when geographical controls are added to the income regression (Table 4.6).

Panel A of Table 4.7 partially confirms the results reported in Table 4.3 and Panel C of Table 4.4. Once I introduce country fixed effects to exploit the panel data, migration share is insignificant with a negative sign while FDI continues to be insignificant. Surprisingly, trade ceases to be significant contradicting the earlier results. Identifying the effects of each individual variable of interest is now impossible.

The insignificance of all the coefficients in Panel A (as well as for the reduced form regressions in Panel C) is an indication that there is too little within country variation over time in the data to identify any of the effects.

As a result I cannot draw any conclusions about the extent to which controlling for migration

Table 4.7. IV estimates of the Income regression including Country Fixed Effects, 1993-2012

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: IV Second-stage regressions (selected results):							
Real TSH_i	0.226	0.156	0.088	-0.178			
	(0.183)	(0.198)	(0.256)	(0.425)			
MSH_i		-1.108		-4.279	-1.011	-4.015	
		(2.383)		(3.748)	(2.478)	(2.835)	
FDI-share$_i$			-0.956	-0.922		-0.820	-1.013
			(1.833)	(1.831)		(1.487)	(1.812)
N	762	762	762	762	762	762	762
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

PANEL B: First-stage regressions (selected results):

	$RTSH_i$	$RTSH_i$	MSH_i	$RTSH_i$	$FDIsh_i$	$RTSH_i$	MSH_i	$FDIsh_i$	MSH_i	MSH_i	$FDIsh_i$	$FDIsh_i$
$\widehat{RTSH}_i$	0.509***	0.513***	-0.031**	0.508***	-0.073	0.512***	-0.031**	-0.078				
	(0.094)	(0.095)	(0.015)	(0.094)	(0.055)	(0.095)	(0.015)	(0.060)				
$\widehat{MSH}_i$		-0.151	-0.040**			-0.149	-0.040**	0.188	-0.047***	-0.048***	0.169	
		(0.128)	(0.016)			(0.128)	(0.016)	(0.268)	(0.015)	(0.015)	(0.261)	
$\widehat{FDIsh}_i$				0.066	-0.154	0.060	-0.007	-0.146		-0.009	-0.152	-0.159
				(0.093)	(0.164)	(0.094)	(0.006)	(0.160)		(0.009)	(0.158)	(0.161)
F-statistic	29.14	14.71	8.312	18.75	0.884	12.63	5.671	0.584	10.47	5.616	0.502	0.967
Partial R^2	0.175	0.177	0.072	0.175	0.013	0.177	0.073	0.020	0.016	0.016	0.010	0.004
SW F-stat	29.14	14.94	14.95	2.820	1.696	3.412	4.223	2.444	10.47	12.55	4.758	0.967
	[0.000]	[0.000]	[0.002]	[0.101]	[0.122]	[0.001]	[0.047]	[0.126]	[0.003]	[0.001]	[0.035]	[0.332]
AP F-stat	29.14	27.21	10.67	56.73	2.500	13.35	21.94	4.485	10.47	13.72	3.555	0.967
	[0.000]	[0.000]	[0.000]	[0.000]	[0.201]	[0.073]	[0.000]	[0.041]	[0.003]	[0.001]	[0.067]	[0.332]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PANEL C: Reduced form (selected results):							
$\widehat{RTSH}_i$	0.115	0.115	0.114	0.113			
	(0.104)	(0.104)	(0.104)	(0.103)			
$\widehat{MSH}_i$		0.021		0.026	0.048	0.053	
		(0.115)		(0.115)	(0.120)	(0.119)	
$\widehat{FDIsh}_i$			0.153	0.154		0.163	0.161
			(0.134)	(0.134)		(0.144)	(0.143)
N	762	762	762	762	762	762	762
R^2	0.960	0.960	0.961	0.961	0.960	0.960	0.960

Notes: Robust standard errors in parentheses. *** p¡0.01, ** p¡0.05, * p¡0.10. The dependent variable in panel A and C is the log of Real GDP_i. The dependent variable for each first-stage regression is reported in the first row of panel B. All specifications include $\ln Population_i$ and $\ln Area_i$ and a constant. F-stat is the first stage F-statistic of excluded instruments. SW F-stat refers to the Sanderson and Windmeijer (2016) multivariate F-statistic of excluded instruments; an improved version of the Angrist and Pischke (2009) F-statistic, denoted by AP F-stat in the table. The null hypothesis is that the endogenous regressor is unidentified. The associated p-values of both tests is reported in [square brackets]. In case of only one endogenous regressor both the SW F-stat and AP F-stat are equal to the F-statistic of excluded instruments. Partial R^2 refers to the squared partial correlation corresponding to the SW F-statistic.

or FDI share affects the size of the estimate for trade share. Nor can I make any statements on the relative importance of each of these globalization flows.

The inclusion of country fixed effects also shows the limitations of the instrument set. The first-stage F-statistic for all specifications are again lower than those reported in Table 4.6, often well below the Staiger and Stock threshold value of 10. The instrument for trade share continues to be strong with a first-stage F-statistic nearing 30, in Panel B column 1. The same cannot be said for migration and FDI share. Especially FDI share is not well identified by the instrument used. The reported coefficient for predicted FDI share in the first-stage regression for FDI share (in Panel B columns 3, 4, 6 and 7) is not significantly different from zero. On top of that, the reported F-statistic of excluded instruments and the Partial R^2 are small and the SW F-stat for FDI-share is low and not significant at the 10% significance level.

The first issue, lack of within country variation over time, may be solved using a larger panel. This will include less developed countries for whom trade, migration and FDI varies more over time. As a result there may be larger within country variation to identify the individual effects.

Initially I opted for a smaller sample to increase the time span of the panel. Availability of bilateral migration and bilateral FDI data is an issue. By restricting the data set to OECD countries meant that I could extend the analysis back in time to 1993. Even then there was too little cross country variation.

4.5.4 Extending the set of countries in the sample

I construct a new data set of 166 countries over 10 years, 2001-2010. The country data set is constructed from the same sources identified in section 4.4. The bilateral data set is constructed using different sources for bilateral migration and bilateral FDI net inflows. Bilateral migration data is sourced from UN Bilateral Migration Stock while UNCTAD Bilateral FDI Statistics is the source for bilateral FDI data. The latter is only available for the period 2001 onwards more than halving the period covered by the data. Additionally, I add a regional dummy for Sub-Saharan Africa to the set of geographic controls, since the sample now includes countries from this region.

I expect that the extension of the number of countries covered provides more variation to identify the effects of real trade share, migration share and FDI share on income. However, the shorter time span covered by the panel means I run the risk that the within country variation may still be too small to identify each individual determinant's effect on income.

Please note that the layout of the tables has not changed and that, as before, Tables 4.8 through 4.11 report robust standard errors that are not adjusted for the use of generated instruments in line with Wooldridge (2002).

The results using the larger sample are not always consistent with those reported for the smaller sample. They do provide evidence that the issues encountered in the previous subsection - the lack of within variation over time and, more importantly, weak instruments - persist in the larger sample.

Panels A and B of Table 4.8 corroborate the results reported in Table 4.4. The effect of trade and migration openness are both positive and significant, although the estimated coefficients for both trade share and migration share are larger in the larger sample compared to the smaller sample. As before, controlling for migration share lowers the estimated coefficient on trade share without the coefficient losing its significance. The same applies to the estimate for migration share; comparing the estimated coefficient for migration share reported in column 5 with that reported in column 2, one notices that the coefficient is lower once one controls for trade share. At the same time controlling for FDI share does little to the size and significance of the estimated coefficient for trade share or for that of migration share (compare column 1 with 3 and column 5 with 6). As before, FDI share does not seem to contribute to explaining the variation in income when it is included with other determinants and even by itself.

The difference between the two samples is the sign on the estimate for FDI share reported in columns 3 and 4 of Panel B, where FDI share is used as a control alongside all other geographic controls. Whereas the smaller sample indicates a positive and significant estimate for FDI share, the estimate for the larger panel is negative and significant. This does not detract from the earlier statement that FDI does not affect the size or significance of the estimates for trade share.

Contrary to the smaller sample, once I control for country fixed effects in the larger sample, Table 4.8 reports negative and significant coefficients for trade share. Furthermore, controlling for migration share or FDI share or both does not change the size of the estimated coefficient.

Table 4.8. OLS estimates of the Income regression for extended sample, 2001-2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Panel A: Simple Income regression				
RealTSH_i	1.522***	1.218***	1.529***	1.218***			
	(0.080)	(0.081)	(0.081)	(0.081)			
MSH_i		3.594***		3.594***	4.919***	4.939***	
		(0.167)		(0.167)	(0.243)	(0.242)	
FDIsh_i			-0.172	-0.001		0.332***	0.201**
			(0.152)	(0.126)		(0.083)	(0.094)
N	1,655	1,655	1,655	1,655	1,655	1,655	1,655
R^2	0.331	0.437	0.331	0.437	0.279	0.282	0.060
Country FE	No	No	No	No	No	No	No
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geo. controls	No	No	No	No	No	No	No
RMSE	1.040	0.953	1.039	0.954	1.079	1.077	1.232
			Panel B: Including Additional Geographic Controls				
RealTSH_i	1.048***	0.885***	1.089***	0.924***			
	(0.075)	(0.063)	(0.078)	(0.066)			
MSH_i		2.749***		2.742***	3.290***	3.287***	
		(0.184)		(0.183)	(0.192)	(0.191)	
FDIsh_i			-0.983**	-0.926**		0.117	0.278
			(0.458)	(0.375)		(0.387)	(0.496)
N	1,266	1,266	1,266	1,266	1,266	1,266	1,266
R^2	0.789	0.823	0.791	0.825	0.786	0.787	0.736
Country FE	No	No	No	No	No	No	No
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geo. controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RMSE	0.591	0.541	0.589	0.539	0.594	0.594	0.661
			Panel C: Using Country Fixed Effects				
RealTSH_i	-0.280***	-0.276***	-0.277***	-0.273***			
	(0.046)	(0.046)	(0.046)	(0.045)			
MSH_i		0.313		0.322	0.527	0.534	
		(0.370)		(0.369)	(0.406)	(0.406)	
FDIsh_i			-0.071**	-0.071**		-0.078**	-0.078**
			(0.028)	(0.028)		(0.031)	(0.031)
N	1,655	1,655	1,655	1,655	1,655	1,655	1,655
R^2	0.989	0.989	0.989	0.989	0.988	0.988	0.988
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RMSE	0.140	0.140	0.140	0.140	0.144	0.144	0.144

Notes: Robust standard errors in parentheses except in Panel B where standard errors are clustered by country. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable in all panels is Expenditure-side real GDP per capita (at chained PPP's) from PWT v.9.0. Specifications reported in panels A and B columns 1 through 7 include $\ln Population_i$ and $\ln Area_i$ as well as constant but these are not reported. Geographic controls are Distance to the Equator, Percentage of land in the tropics, distance of the i's centroid to the coast, dummy equal to 1 if i is landlocked, dummy equal to 1 if i is in Latin-America, a dummy equal to 1 if i is either Australia, Canada, New Zealand or the United States, dummy equal to 1 if i is a (former) British colony, dummy equal to 1 if i is a (former) French colony, climate indexes of average temperature and humidity as well as soil quality, dummy equal to 1 if there is an incidence of yellow fever, an index for presence of malaria in 1994, and a measure of oil reserves. Constant is included in all regressions but not reported.

Meanwhile, migration share whose coefficient was negative and significant for the smaller sample, ceases to be significant determinant of income. FDI share's effect, on the other hand, is significant in the large sample while the coefficient was not significantly different from zero in the smaller sample. Like trade, though, it is negative. So, according to these results openness to migration has no effect on income while openness to trade and FDI has a negative effect on income.

Table 4.9. IV estimates of the Income regression, 2001-2010

	(1)	(2)		(3)		(4)			(5)	(6)		(7)
Panel A: Second-stage regressions (selected results):												
$RTSH_i$	3.674***	4.786***		1.096		13.474						
	(0.427)	(1.770)		(1.679)		(73.109)						
MSH_i		-4.180				-19.615			8.941***	2.371		
		(5.799)				(123.186)			(0.983)	(2.260)		
$FDIsh_i$				10.673*		-18.964				14.864***		9.008
				(5.731)		(170.355)				(5.676)		(6.775)
N	1,655	1,655		1,655		1,655			1,655	1,655		1,655
Country FE	No	No		No		No			No	No		No
Time FE	Yes	Yes		Yes		Yes			Yes	Yes		Yes
Geo. controls	No	No		No		No			No	No		No
RMSE	1.394	1.815		2.226		5.947			1.179	2.891		2.023
Panel B: First-stage regressions (selected results):												
	$RTSH_i$	$RTSH_i$	MSH_i	$RTSH_i$	$FDIsh_i$	$RTSH_i$	MSH_i	$FDIsh_i$	MSH_i	MSH_i	$FDIsh_i$	$FDIsh_i$
$\widehat{RTSH}_i$	0.466***	0.325***	0.055***	0.466***	0.115***	0.291***	0.019	0.115***				
	(0.094)	(0.102)	(0.021)	(0.094)	(0.040)	(0.104)	(0.020)	(0.044)				
$\widehat{MSH}_i$		4.572***	2.252***			5.409***	3.135***	-0.002	2.752***	3.332***	1.200***	
		(1.298)	(0.334)			(1.370)	(0.396)	(0.244)	(0.287)	(0.320)	(0.383)	
$\widehat{FDIsh}_i$				0.004	0.083**	-0.263*	-0.278***	0.083**		-0.290***	0.008	0.060
				(0.127)	(0.040)	(0.146)	(0.045)	(0.039)		(0.042)	(0.045)	(0.043)
F-statistic	24.68	25.93	47.25	12.39	6.439	19.81	37.40	4.714	91.72	54.66	6.266	1.954
Partial R^2	0.0477	0.0588	0.0783	0.0477	0.0170	0.0608	0.107	0.0170	0.0722	0.106	0.00617	0.000689
SW F-stat	24.68	8.232	7.971	2.959	3.177	0.0290	0.0293	0.0283	91.72	8.436	6.823	1.954
	[0.000]	[0.067]	[0.005]	[0.012]	[0.075]	[0.868]	[0.864]	[0.866]	[0.000]	[0.004]	[0.009]	[0.162]
AP F-stat	24.68	3.366	7.436	6.374	4.269	0.0275	0.219	0.0835	91.72	59.86	6.755	1.954
	[0.000]	[0.004]	[0.006]	[0.086]	[0.039]	[0.865]	[0.640]	[0.773]	[0.000]	[0.000]	[0.009]	[0.162]
Panel C:Reduced form (selected results):												
$\widehat{RTSH}_i$	1.711***	1.328***		1.739***		1.370***						
	(0.178)	(0.185)		(0.181)		(0.201)						
$\widehat{MSH}_i$		12.470***				11.436***			24.610***	25.741***		
		(2.635)				(3.057)			(2.291)	(2.392)		
$\widehat{FDIsh}_i$				0.890***		0.325				-0.566*		0.537**
				(0.254)		(0.305)				(0.297)		(0.271)
R^2	0.135	0.145		0.138		0.145			0.112	0.113		0.061

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable in panel A and C is the log of Real GDP_i. The dependent variable for each first stage regression is reported in the first row of panel B. All specifications include $\ln Population_i$ and $\ln Area_i$ and a constant. F-stat is the first stage F-statistic of excluded instruments. SW F-stat refers to the Sanderson and Windmeijer (2016) multivariate F-statistic of excluded instruments, an improved version of the Angrist and Pischke (2009) F-statistic, labeled AP F-stat in this table. The null hypothesis of these tests is that the endogenous regressor is unidentified. The associated p-values of both tests is reported in [square brackets]. In case of only one endogenous regressor both the SW F-stat and AP F-stat are equal to the F-statistic of excluded instruments. Partial R^2 refers to the squared partial correlation corresponding to the SW F-statistic.

Table 4.9 and Table 4.10 report the results using 2SLS analysis without country fixed effects; the first does not include any geographic controls other than country size and the second includes the geographic controls of vector $\mathbf{X}_i$ in equation (4.1). The instrument used for each endogenous regressor, trade, migration and FDI, is generated using the OLS estimates of the bilateral equation (4.2) without country fixed effects. This ensures that the instrumentation strategy is identical to the one used for the smaller sample.[9]

Both tables report that trade share is positive and significantly different from zero when it is a sole determinant and when controlling for migration share. As before, once we additionally control for FDI share, trade openness' effect ceases to be significantly different from zero.

Table 4.10. Estimates of the Income Regression using extended panel and additional geographic controls, 2001-2010

	(1)	(2)		(3)		(4)			(5)	(6)		(7)
Panel A: Second-stage regressions (selected results):												
$RTSH_i$	1.686***	1.458***		3.376		18.987						
	(0.195)	(0.426)		(2.557)		(202.332)						
MSH_i		1.055				-30.237			5.106***	4.249***		
		(1.437)				(365.012)			(0.615)	(0.684)		
$FDIsh_i$				-7.771		-49.507				2.434*		4.624***
				(11.994)		(565.448)				(1.256)		(1.572)
N	1,266	1,266		1,266		1,266			1,266	1,266		1,266
Country FE	No	No		No		No			No	No		No
Time FE	Yes	Yes		Yes		Yes			Yes	Yes		Yes
Geo. controls	Yes	Yes		Yes		Yes			Yes	Yes		Yes
RMSE	0.611	0.569		0.882		5.475			0.608	0.606		0.693
Panel B: First-stage regressions (selected results):												
	$RTSH_i$	$RTSH_i$	MSH_i	$RTSH_i$	$FDIsh_i$	$RTSH_i$	MSH_i	$FDIsh_i$	MSH_i	MSH_i	$FDIsh_i$	$FDIsh_i$
$\widehat{RTSH}_i$	0.680***	0.371***	-0.001	0.575***	0.113***	0.358***	0.014	0.117***				
	(0.074)	(0.064)	(0.017)	(0.079)	(0.033)	(0.065)	(0.019)	(0.038)				
$\widehat{MSH}_i$		6.749***	3.226***			6.340***	3.686***	-0.107	3.223***	3.758***	0.491**	
		(0.866)	(0.302)			(0.992)	(0.276)	(0.251)	(0.252)	(0.254)	(0.222)	
$\widehat{FDIsh}_i$				0.843***	0.278**	0.257	-0.289***	0.287**		-0.282***	0.339**	0.403***
				(0.222)	(0.113)	(0.218)	(0.075)	(0.125)		(0.073)	(0.150)	(0.150)
F-statistic	84.58	75.95	92.06	73.88	6.355	60.96	81	4.924	163.6	113.9	5.820	7.227
Partial R^2	0.0807	0.125	0.144	0.0927	0.143	0.126	0.157	0.143	0.144	0.156	0.0953	0.0885
SW F-stat	84.58	26.28	26.47	1.513	1.413	0.00836	0.00840	0.00832	163.6	96.18	8.689	7.227
	[0.000]	[0.000]	[0.000]	[0.219]	[0.208]	[0.891]	[0.818]	[0.890]	[0.000]	[0.000]	[0.003]	[0.007]
AP F-stat	84.58	33.97	46.22	2.367	1.584	0.0187	0.0528	0.0190	163.6	176.9	9.143	7.227
	[0.000]	[0.000]	[0.000]	[0.124]	[0.235]	[0.927]	[0.927]	[0.927]	[0.000]	[0.000]	[0.003]	[0.007]
Panel C:Reduced form (selected results):												
$\widehat{RTSH}_i$	1.146***	0.541***		1.060***		0.573***						
	(0.129)	(0.158)		(0.138)		(0.171)						
$\widehat{MSH}_i$		13.242***				14.241***			16.457***	17.166***		
		(2.637)				(2.418)			(2.427)	(2.264)		
$\widehat{FDIsh}_i$				0.689		-0.628				-0.374		1.865***
				(0.552)		(0.625)				(0.655)		(0.654)
R^2	0.747	0.755		0.747		0.755			0.753	0.753		0.739

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable in panel A and C is the log of Real GDP_i. All specifications include $\ln Population_i$ and $\ln Area_i$ and a constant. Geographic controls are Distance to the Equator, Percentage of land in the tropics, distance of the i's centroid to the coast, dummy equal to 1 if i is landlocked, dummy equal to 1 if i is in Latin-America, a dummy equal to 1 if i is either Australia, Canada, New Zealand or the United States, dummy equal to 1 if i is a (former) British colony, dummy equal to 1 if i is a (former) French colony, climate indexes of average temperature and humidity as well as soil quality, dummy equal to 1 if there is an incidence of yellow fever, an index for presence of malaria in 1994, and a measure of oil reserves. F-stat is the first stage F-statistic of excluded instruments. SW F-stat refers to the Sanderson and Windmeijer (2016) multivariate F-statistic of excluded instruments, an improved version of the Angrist and Pischke (2009) F-statistic, labeled AP F-stat in this table. The null hypothesis of these tests is that the endogenous regressor is unidentified. The associated p-values of both tests is reported in [square brackets]. In case of only one endogenous regressor both the SW F-stat and AP F-stat are equal to the F-statistic of excluded instruments. Partial R^2 refers to the squared partial correlation corresponding to the SW F-statistic.

Migration share is not significantly different from zero unless it is the sole determinant, in columns 5 of Table 4.9 and 4.10, or controlled for by both FDI share as well as all geographic

[9] Appendix 4D reports the correlation coefficients between different types of instruments and the actual share.

controls in column 6 of Table 4.10. This result is in contrast with the results for the smaller sample where migration is consistently significantly different from zero unless one controls for FDI share as well as geographic controls as in column 6 of Table 4.6. Similar to trade share, the effect of migration share is insignificant when controlling for the other two determinants, trade share and FDI share, irrespective of the geographic controls used.

The significance and sign of the estimate fro FDI share varies across the two tables. It is significant and positive when used as a control for trade and migration share in Table 4.9 and ceases to be when used as the only determinant of income. In contrast Table 4.10 reports a significant and positive estimate for FDI share when used individually in column 7 or as a control for migration share in column 6. However, it is negative and significant when used as a control for trade share in column 3.

These results indicate that there may be issues with identification. I now turn to the evaluation of the instrumentation strategy by looking at the strength of the generated instruments.

For trade share and migration share the predicted shares can be considered strong instruments, when income is regressed on trade share or migration share individually. Panel B reports a large first stage F-statistic. Also when used simultaneously, as in column 2, the p-values of the SW F-statistic indicate that we cannot reject the null-hypothesis of weak instruments and the instruments are able to identify the effect of each endogenous regressor.

Predicted FDI share, on the other hand, is not a strong instrument. Column 7 of both Table 4.9 and 4.10 report a low first-stage F-statistic for excluded instruments when FDI share is used individually. A low first-stage F-statistic is also reported for FDI share where FDI share is a control for either trade share or migration share or both. Additionally, when FDI share is used as a control for trade share the p-values for the SW F-statistic reported in columns 3 exceed the desired significance levels. Although, the null hypothesis for the SW F-statistic that the instrument is weak cannot always be rejected when FDI share controls migration share, see the reported p-values in column 6 of Panel B, the results show that the instrument for FDI share is not strong.

The reported results in both tables indicate that the instrumentation strategy employed does not adequately lead to strong instruments for each of these regressors when used simultaneously to explain the variation in income. Once I control for both migration share and FDI share using the respective instrument, all instruments are weak as indicated by the extremely low SW F-stats reported in panel B column 4 and the associated p-values that exceed 0.81.

Table 4.11. IV estimates of the Income regression for the extended sample including country fixed effects, 2001-2010

	(1)	(2)		(3)		(4)			(5)	(6)	(7)
Panel A: Second-stage regressions (selected results):											
RTSH_i	0.572*	0.305		-0.812		1.622					
	(0.324)	(0.526)		(1.361)		(13.645)					
MSH_i		-3.845				-35.267			-5.367	-11.731	
		(5.544)				(228.256)			(3.924)	(16.152)	
FDIsh_i				-2.691		6.798				1.139	238.359
				(2.583)		(55.087)				(2.642)	(33,365.127)
Observations	1,655	1,655		1,655		1,655			1,655	1,655	1,655
Country FE	Yes	Yes		Yes		Yes			Yes	Yes	Yes
Time FE	Yes	Yes		Yes		Yes			Yes	Yes	Yes
RMSE	0.166	0.164		0.397		1.137			0.162	0.282	33.43
Panel B: First-stage regressions (selected results):											
	RTSH_i	RTSH_i	MSH_i	RTSH_i	FDIsh_i	RTSH_i	MSH_i	FDIsh_i	MSH_i	MSH_i FDIsh_i	FDIsh_i
$\widehat{RTHS}_i$	0.844***	0.874***	-0.064*	0.843***	-0.434*	0.873***	-0.064*	-0.466*			
	(0.315)	(0.306)	(0.035)	(0.315)	(0.241)	(0.306)	(0.035)	(0.252)			
$\widehat{MSH}_i$		-10.044**	1.926*			-9.978**	1.932*	10.853*	1.874*	1.880*10.477*	
		(4.135)	(1.069)			(4.104)	(1.072)	(6.152)	(1.072)	(1.0(5.9)82)	
$\widehat{FDIshare}_i$				0.157*	0.001	0.147	0.013	0.012		0.01310	-0.001
				(0.088)	(0.075)	(0.090)	(0.013)	(0.074)		(0.0(1.3)78)	(0.080)
F-statistic	7.191	7.023	2.521	5.051	2.258	6.028	2.771	2.196	3.058	1.82682	0.000
Partial R^2	0.0361	0.0552	0.0554	0.0382	0.00668	0.0570	0.0564	0.0222	0.0422	0.04130145	1.71e-08
SW F-stat	7.191	1.533	1.147	1.029	1.035	0.0205	0.0246	0.0233	3.058	0.31306	4.54e-05
	[0.008]	[0.107]	[0.144]	[0.071]	[0.199]	[0.886]	[0.876]	[0.879]	[0.082]	[0.5[0.838]	[0.995]
AP F-stat	7.191	2.629	2.153	3.293	1.661	0.481	0.266	0.0610	3.058	2.13022	4.54e-05
	[0.008]	[0.217]	[0.286]	[0.312]	[0.311]	[0.489]	[0.607]	[0.805]	[0.082]	[0.1[0.681]	[0.995]
Panel C:Reduced form (selected results):											
$\widehat{RTHS}_i$	0.482*	0.514**		0.483*		0.515**					
	(0.249)	(0.246)		(0.251)		(0.247)					
$\widehat{MSH}_i$		-10.471**				-10.535***			-10.058**	-10.120**	
		(4.051)				(4.039)			(4.119)	(4.109)	
$\widehat{FDIshare}_i$				-0.131		-0.142				-0.139	-0.129
				(0.099)		(0.092)				(0.095)	(0.103)
R^2	0.988	0.989		0.988		0.989			0.988	0.989	0.988

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable in panel A and C is the log of Real GDP_i. All specifications include $\ln Population_i$ and $\ln Area_i$ and a constant. F-stat is the first stage F-statistic of excluded instruments. SW F-stat refers to the Sanderson and Windmeijer (2016) multivariate F-statistic of excluded instruments, an improved version of the Angrist and Pischke (2009) F-statistic, labeled AP F-stat in this table. The null hypothesis of these tests is that the endogenous regressor is unidentified. The associated p-values of both tests is reported in [square brackets]. In case of only one endogenous regressor both the SW F-stat and AP F-stat are equal to the F-statistic of excluded instruments. Partial R^2 refers to the squared partial correlation corresponding to the SW F-statistic.

Even though the results for the larger sample so far have not shown a marked improvement on those reported for the smaller sample, I complete the analysis by reporting the estimation results when including country fixed effects.

Table 4.11 reports a coefficient for trade share that is a positive determinant of income and significant at the 10% significance level. Its size of 0.572 is comparable to that in the literature.

At the same time, the first-stage F-statistic in column 1 is large enough for the instrument for trade to be considered a strong instrument.

Controlling for migration share or FDI share or both, causes the effect of trade share to become insignificant. In contrast to the smaller sample, the size of coefficient for trade share does not necessarily decrease with the addition of the controls migration share and/or FDI share as reported in Columns 2, 3 and 4 of Table 4.11.

All other estimates are insignificant. As in Tables 4.9 and 4.10, results for the first stage reported in Panel B of Table 4.11 indicate that the instrument for migration is strong while that for FDI share is not except in column 6 when income is regressed on migration share and FDI share.

Column 4 corroborates earlier results that the use of all three determinants simultaneously does not lead to significant results. At the same time they provide evidence that the instrument set does not adequately identify the exogenous variation of each of the endogenous regressors in the second stage leading to inconsistent results.

4.6 Discussion of the results

In the previous section, I state that the reported results suggest that both data sets used suffer from the lack of identification. For both samples it seems that the within country variation over time is insufficient to identify the effects of each of the determinants of income, especially when using country fixed effects. An indication of this is the switching of the sign of the estimate for migration share from positive to negative as country fixed effects substitute the commonly used set of geographic controls. This occurs when estimating the specifications using OLS as well as 2SLS and the generated instruments.

One reason for this is the limited time span of the samples used. Unfortunately, I'm unable to extend the sample period further back because of limited availability of bilateral FDI data needed to generate the FR instrument for FDI. As a robustness check I estimate the specifications for two individual cross sections for the large sample. Identification of the effects will now come from the variation across countries, instead of within country variation over time which is limited in the panel by the short time span covered. The results reported in Appendix 4E, however, show no improvement in significance of the determinants or strength of the instruments when used simultaneously. Table E1 does not report any significant results for the cross section using data for 2001 while in the results for cross section for 2005, reported in Table E2, only the estimate for trade share is significant. Therefore, the limited time span is not the only cause hindering identification of each singular determinant of interest.

Additional to the limited time span of my data, multicollinearity between the determinants is a possible reason that I cannot identify the individual effects of each of the three determinants on income.

The results indicate that the issue of multicollinearity is greatest between trade and FDI share than between migration share and either trade share or FDI share. In the majority of the results FDI share is an insignificant determinant of income when used simultaneously with trade in the income regression, even without the use of country fixed effects. In all cases it did little to affect the size of the estimate for trade share or add to the variation of income explained by the determinants. Even the 'outlier' result in column 3 of Panel A of Table 4.9 where FDI share is significant while trade share was not, reinforces the conclusion; either trade share or FDI share explains the cross country and within country variation of income.

The combination of limited time span and multicollinearity of the endogenous regressors also affects the validity of the instrumentation strategy. The previous section has provided evidence that predicted trade share, predicted migration share and predicted FDI share are not strong instruments for actual trade share, actual migration share and actual FDI share, respectively, when used simultaneously. And in the case of FDI share, the instrumentation strategy, although plausible, does not produce strong instruments even in those specifications where FDI share is the sole determinant of income (see column 7 in each of the tables presented in the previous section).

I followed OP in assuming that the sensitivity of each of the endogenous regressors to the covariates in the bilateral equation would be different across the different regressors. Although there is some variation over time and across the determinants as shown in the Figures in Appendix 4B, like Andersen and Dalgaard (2011) I find that the estimates for the bilateral equation for bilateral trade and bilateral travel are impacted in a similar fashion. This feature of their results does not allow them to identify which geographic covariate in the bilateral equation influences income through trade and which covariate affects income through travel.

They conclude from their results of the second stage that there is multicollinearity between trade and travel. As a result they cannot draw any conclusions about the relative importance of trade versus travel. The estimates reported here suffer from the same problem.

One can argue that this is caused by the approach to estimate the bilateral equation and generate the instrument for each cross section as it does not make full use of the information contained in the panel. However, estimating the bilateral equation for the panel while allowing for time varying coefficients on distance and including time as well as country fixed effects[10] to generate the instrument, does not change the basic results as the results reported in Appendix 4F demonstrate. So, it is not the cross-sectional approach but limited time span of the panel that is causing problems. Due to the limited time span covered by the data, both approaches do not generate instrumental variables that have enough within variation over time to allow for identification of the exogenous variation of the associated endogenous regressor.

The lack of variation in sensitivities to changes in the covariates could be circumvented by using different estimation techniques to generate each instrument. Using the same estimation technique leads to the high correlation amongst the instruments. Particularly as the changes in the estimates over time are not very different for trade share, migration share and FDI share. OP use a different estimation technique to generate their instrument for trade share than they use to generate the instrument for migration share; for the former they use OLS estimates and for the latter they use the estimates from the Poisson Pseudo Maximum Likelihood estimation (henceforth PPML) of the same bilateral specification.[11] The latter estimation technique makes use of the information contained in the bilateral observations of zero bilateral trade or zero bilateral migration. Santos Silva and Tenreyro (2006) argue that estimating the log linear form of a gravity equation using OLS and as a result discarding the information contained in the observations of zero bilateral trade, will bias the estimates in the gravity equation.

This means that using different estimation techniques to generate each instruments artificially reduces the similarity in the estimates for trade, migration and FDI share. In the case of

[10] I employ the methodology used by Feyrer (2009b) as well as Pascali (2017) and estimate a bilateral equation containing two measures of bilateral distance, for the panel. The time varying coefficients on the two bilateral distance measures, sea distance and air distance, allow for the sensitivities of the volume of trade to change as exogenous technological change affects the relative transport costs of sea to air transport. See Appendix 4F for more information and results.

[11] OP argue that PPML is justified given the many zero observations of bilateral migration that they encounter in their data set.

using OLS for trade and using PPML estimation for migration allows biased estimates for one instrument, predicted trade share, while eliminating this bias for another instrument, predicted migration share. And yet, there is no fundamental reason to exclude the information contained in zero observations for trade while at the same time including that information for migration. Therefore, this is not a valid solution to the problem of insufficient variation between the instruments.

Another source causing the lack of variation across the three instruments is that there is a common variation to each instrument, namely the variation of the covariates in the bilateral equation across bilateral pairs.[12] Each of these instruments captures this common variation of the covariates in the bilateral equation, precisely because the bilateral equation is used to generate an instrument for trade share, migration share and FDI share. As a consequence, one cannot interpret the estimates generated using these instruments in the traditional sense for the simple reason that it is impossible to vary the determinant of interest, while holding all other determinants constant.

Ultimately, this is a fundamental flaw to the instrumentation strategy as it holds even in cases where the assumptions of differing sensitivities to variations in the covariates is realized in practice. Therefore, the reported results and subsequent discussion do not allow for definitive statements on the effects of trade, migration or FDI on income. Nor can I confidently make any statements about the relative importance of trade (openness) versus openness to migration and/or openness to FDI.

What does this all mean for the hypothesis that one should control for FDI (share) in any income regression using the FR instrument for trade openness? Although the results are inconsistent as a result of the weak instrument set employed, the reported results suggest that one does not need to control for FDI when estimating the effect of trade on income using geography to generate the instrument for trade. The estimate for trade share is not affected when FDI share is controlled for. Neither is the estimate for migration share. Additionally, in specifications where it is the only determinant of income, FDI share is often insignificant and FDI share does not contribute to explaining the variation of income in any specifications in which it is used.

[12]Except for population, all covariates in the bilateral equation are time invariant.

However, despite the weaknesses identified above, I cannot discount the argument by Feyrer (2009a) that the FR instrument captures more than just the exogenous variation of trade, i.e. that the instrument actually captures the exogenous variation of globalization as determined by geography. For instance, when controlling for migration, trade's estimate is smaller than when it is the singular determinant of interest. This could explain why the 2SLS estimate for trade share is larger than the OLS estimate, a surprising feature of the results originally identified by FR. Given the simultaneity and reverse causality argument that income also contributes to trade volume, i.e. richer countries trade more, one would expect the OLS estimate to be biased upward as opposed to downward. Following the reasoning first proposed by Feyrer (2009a), the downward bias in the OLS estimate is the result of the FR instrument capturing more than predicted trade, namely predicted openness based on geography.

4.7 Conclusion

This paper set out to investigate the effect of trade openness on income once we control for other globalization flows that affect income, like migration and FDI.

The results identify a downward adjustment in the size of the estimated effect that trade openness has on income when controlling for migration. Controlling for FDI does little to the estimates for trade. However, the results are not consistently significant across different samples to make definitive statements about the effect of individual determinants or their relative importance.

There are several reasons for the lack of consistent, significant results. One is that the limited time period covered by the panel as well as the possible multicollinearity between the endogenous regressors, means that there is too little variation to identify individual effects.

More important though are the conclusions in the instrumentation strategy employed in the paper. The features of the data mean that there is too little variation across the instruments employed. This causes the instruments to be weak when used simultaneously. In part the limited time span covered by the data and similar drivers of bilateral trade, bilateral migration and bilateral FDI mean that estimates of the bilateral equation are unlikely to be very different for each of these bilateral flows. This is one reason that the variation across the instruments will be similar.

More fundamental though is the fact that each instrument relies on the variation of the common covariates in the bilateral equation. The consequence of this is that one cannot interpret the 2SLS estimates when using these instruments simultaneously, even if the reported results are significant.

From an economic perspective the conclusions that can be drawn are less satisfying than hoped for. Yes, trade openness affects income positively while migration and FDI do not. However, the results do not allow us to say anything about the importance of trade openness to income relative to that of a country's openness to migration or to its openness to FDI.

Where to go from here? Although promising and intuitively appealing the FR instrument should not be used as a strategy to instrument for more than one globalization flow. Future research into the effect of trade or trade openness on income in a cross-country panel data analysis should control for other globalization flows but use instruments for migration and FDI whose variation is independent of the variation underlying the instrument for trade. Until the literature finds these instruments it would advisable to interpret results using the FR methodology in terms of investigating the effects of globalization on income, as opposed to the effect of trade alone.

References

Acemoglu, D., Johnson, S. and Robinson, J. A. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation, *The American Economic Review* **91**(5): 1369–1401.

Adserà, A. and Pytliková, M. (2015). The Role of Language in Shaping International Migration, *The Economic Journal* **125**(586): F49–F81.

Alcalá, F. and Ciccone, A. (2004). Trade and Productivity, *Quarterly Journal of Economics* **119**(2): 613–646.

Andersen, T. B. and Dalgaard, C.-J. (2011). Flows of people, flows of ideas, and the inequality of nations, *Journal of Economic Growth* **16**(1): 1–32.

Anderson, J. E. (2011). The Gravity Model, *Annual Review of Economics* **3**(1): 133–160.

Angrist, J. D. and Pischke, J.-S. (2009). *Mostly harmless econometrics: an empiricist's companion*, Princeton University Press, Princeton.

Blonigen, B. A. and Piger, J. (2014). Determinants of foreign direct investment, *Canadian Journal of Economics* **47**(3): 775–812.

Borensztein, E., De Gregorio, J. and Lee, J.-W. (1998). How does foreign direct investment affect economic growth?, *Journal of International Economics* **45**(1): 115–135.

de Mello, L. R. (1997). Foreign direct investment in developing countries and growth: A selective survey, *Journal of Development Studies* **34**(1): 1–34.

Easterly, W. and Levine, R. (2003). Tropics, germs, and crops: how endowments influence economic development, *Journal of Monetary Economics* **50**(1): 3–39.

Edwards, S. (1993). Openness, Trade Liberalization, and Growth in Developing Countries, *Journal of Economic Literature* **31**(3): 1358–1393.

Edwards, S. (1998). Openness, Productivity and Growth: What do We Really Know?, *The Economic Journal* **108**(447): 383–398.

Estevadeordal, A. and Taylor, A. M. (2013). Is the Washington Consensus Dead? Growth, Openness, and the Great Liberalization, 1970s-2000s, *Review of Economics and Statistics* **95**(5): 1669–1690.

Feenstra, R. C., Inklaar, R. and Timmer, M. P. (2015). The Next Generation of the Penn World Table†, *American Economic Review* **105**(10): 3150–3182.

Feyrer, J. (2009a). Distance, Trade, and Income - The 1967 to 1975 Closing of the Suez Canal as a Natural Experiment, *Working Paper 15557*, National Bureau of Economic Research.

Feyrer, J. (2009b). Trade and Income – Exploiting Time Series in Geography, *Working Paper 14910*, National Bureau of Economic Research.

Frankel, J. A. and Romer, D. (1999). Does Trade Cause Growth?, *American Economic Review* **89**(3): 379–399.

Freund, C. and Bolaky, B. (2008). Trade, regulations, and income, *Journal of Development Economics* **87**(2): 309–321.

Hall, R. E. and Jones, C. I. (1999). Why Do Some Countries Produce So Much More Output Per Worker Than Others?, *The Quarterly Journal of Economics* **114**(1): 83–116.

Hanson, G. H. (2009). The Economic Consequences of the International Migration of Labor, *Annual Review of Economics* **1**(1): 179–208.

Head, K., Mayer, T. and Ries, J. (2010). The erosion of colonial trade linkages after independence, *Journal of International Economics* **81**(1): 1–14.

International Monetary Fund (n.d.). Direction of Trade Statistics.

Irwin, D. A. and Terviö, M. (2002). Does trade raise income?: Evidence from the twentieth century, *Journal of International Economics* **58**(1): 1–18.

Li, X. and Liu, X. (2005). Foreign Direct Investment and Economic Growth: An Increasingly Endogenous Relationship, *World Development* **33**(3): 393–407.

Madsen, J. B. (2016). Barriers to Prosperity: Parasitic and Infectious Diseases, IQ, and Economic Development, *World Development* **78**: 172–187.

Mayda, A. M. (2010). International migration: a panel data analysis of the determinants of bilateral flows, *Journal of Population Economics* **23**(4): 1249–1274.

Mayer, T. and Zignago, S. (2011). Notes on CEPII's distances measures: the GeoDist Database, *Working Paper 2011-25*, CEPII.

Melitz, J. and Toubal, F. (2014). Native language, spoken language, translation and trade, *Journal of International Economics* **93**(2): 351–363.

Noguer, M. and Siscart, M. (2005). Trade raises income: a precise and robust result, *Journal of International Economics* **65**(2): 447–460.

OECD (2011). International Migration Database.

OECD (n.d.). International Direct Investment Database.

Ortega, F. and Peri, G. (2014). Openness and income: The roles of trade and migration, *Journal of International Economics* **92**(2): 231–251.

Ozden, C., Parsons, C. R., Schiff, M. and Walmsley, T. L. (2011). Where on Earth is everybody? : the evolution of global bilateral migration 1960-2000, *The World Bank economic review* **25**(1 (2011)): 12–56.

Pascali, L. (2017). The Wind of Change: Maritime Technology, Trade, and Economic Development, *American Economic Review* **107**(9): 2821–2854.

Portes, R. and Rey, H. (2005). The determinants of cross-border equity flows, *Journal of International Economics* **65**(2): 269–296.

Rodriguez, F. and Rodrik, D. (2001). Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence, *NBER Macroeconomics Annual 2000*, Vol. 15, MIT PRess, pp. 261–338.

Rodrik, D., Subramanian, A. and Trebbi, F. (2004). Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development, *Journal of Economic Growth* **9**(2): 131–165.

Sanderson, E. and Windmeijer, F. (2016). A weak instrument F-test in linear IV models with multiple endogenous variables, *Journal of Econometrics* **190**(2): 212–221.

Santos Silva, J. M. C. and Tenreyro, S. (2006). The Log of Gravity, *The Review of Economics and Statistics* **88**(4): 641–658.

Staiger, D. and Stock, J. H. (1997). Instrumental Variables Regression with Weak Instruments, *Econometrica* **65**(3): 557–586.

UNCTAD (n.d.a). Bilateral FDI Statistics.

UNCTAD (n.d.b). World Investment Report.

United Nations, Department of Economic and Social Affairs, Population Division (n.d.). Trends in international migrant stock: The 2015 revision.

Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data*, Cambridge, Mass. ; London : MIT Press.

World Bank (n.d.). World Development Indicators.

4A Data Description

Bilateral data

Bilateral trade Bilateral trade data is sourced from Direction of Trade Statistics (DoTS). In order to ensure symmetry within each dyad, i.e. that bilateral trade from A to B equals bilateral trade from B to A, the measure of bilateral trade for each of dyad is the sum of bilateral exports and bilateral imports of the country reporting both bilateral flows. If both countries in a dyad report both bilateral exports and bilateral imports, the highest sum reported is taken as the measure of bilateral trade for the dyad. The values of bilateral exports and bilateral imports, whose sum is taken as the measure of bilateral trade for the dyad, are attributed to the reporting country. Then the value of the reporting country's exports are multiplied by 1.1 (to account for cost, insurance and freight) and taken as the value of the partner's imports. At the same time the value of the reporting country's imports are divided by 1.1 and taken as the measure of the partner's exports.

Real bilateral trade share is constructed by adjusting nominal exports and nominal imports for the price level of exports and the price level of imports, respectively before summing. The sum of 'real exports' and 'real imports' is then divided by the reporter country's Output-side GDP measure at current PPP's[13]. All price levels and the output-side measure of GDP are sourced from the Penn World Tables (PWT) v9.0.

Bilateral migration The bilateral migration data is sourced from the OECD Migration Database. Although the OECD has a series for migrant inflows, I choose to use the series for migrant stocks because more countries report this across a larger set of partner countries. The preferred series is the migrant stock reported by country of birth. The alternate series that report migrants by nationality, will under report the actual migrant stock because migrants that lose their original nationality upon naturalization in the destination country are not included in the figure of migrant stock by nationality (Ozden et al., 2011). To maximize the number of non-zero observations for bilateral migrant stocks, the observation for migrant stock by nationality is used in those cases where countries do not report bilateral migrant stock by country of birth but report bilateral stocks by nationality.

Bilateral foreign direct investment We use the measure of net inflows collected using the BDMB3 guidelines which preceded the current guidelines used by international statistical institutions to compile databases. The reason for using BDMB3 instead of BDMB4 is that these provide us with more coverage back in time.

It is important to note that in the bilateral database the migration stock per partner and bilateral FDI inflows is very limited for the following reporters: Chili, Estonia, Israel and Slovenia. These countries joined the OECD in 2010 so data is available for the latter years in the sample.

The set of 39 reporter countries in the OECD sample include: Australia, Austria, Belgium, Bulgaria (non-member), Canada, Chili, Czech Republic, Denmark, Estonia, Finland, France,

[13]The choice to use output-side GDP at current PPP's is motivated by the set up of the PWT. All price levels are

Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania (non-member), Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania (non-member), Russia (non-member), Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States of America.

The 183 partner countries include the 39 reporter listed in the previous paragraph and: **Aruba**, Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belize, Benin, Bermuda, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Central African Republic, Chad, China, Columbia, Comoros, Congo, Costa Rica, Croatia, Cuba, Cyprus, Democratic Republic of the Congo, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Equatorial Guinea, **Faroe Islands**, Fiji, Gabon, Gambia, Georgia, Ghana, **Greenland**, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, India, Indonesia, Iran, Iraq, Ivory Coast, Jamaica, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Laos, Lebanon, Lesotho, Liberia, Libya, (FYR) Macedonia, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, **New Caledonia**, Nicaragua, Niger, Nigeria, North Korea, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Qatar, Rwanda, Samoa, Sao Tome & Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Solomon Islands, Somalia, South Africa, Sri Lanka, St. Kitts & Nevis, St. Lucia, St. Vincent & the Grenadines, Sudan, Suriname, Swaziland, Syria, Tajikistan, Tanzania, Thailand, Togo, Tonga, Trinidad & Tobago, Tunisia, Turkmenistan, Uganda, Ukraine, Uruguay, United Arab Emirates, Uzbekistan, Venezuela, Vietnam, Vanuatu, Yemen, Zambia and Zimbabwe.

For migration the sample of partner countries include the 183 countries above excluding those in bold text while including the following 9 countries. These are: Antigua, East Timor, Eritrea, Micronesia, Kiribati, Marshall Islands, Palau, Palestine, Puerto Rico, San Marino, Tuvalu and Taiwan

For FDI the sample of partner countries include the 183 countries above and: Anguilla, Antigua, Bhutan, Cayman Islands, East Timor, Eritrea, French Polynesia, Micronesia, Kiribati, Marshall Islands, Northern Mariana Islands, Montserrat, Palau, Palestine, San Marino, Turks & Caicos Islands, Tuvalu, Taiwan and British Virgin Islands.

The set of 166 reporter countries in the larger sample include: Aruba, Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China, Columbia, Comoros, Congo, Costa Rica, Croatia, Cyprus, Czech Republic, Democratic Republic of the Congo, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Equatorial Guinea, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Haiti, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Ivory Coast, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Kyrgyzstan, Laos, Latvia, Lebanon, Liberia, Lithuania, Luxembourg, (FYR) Macedonia, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, the

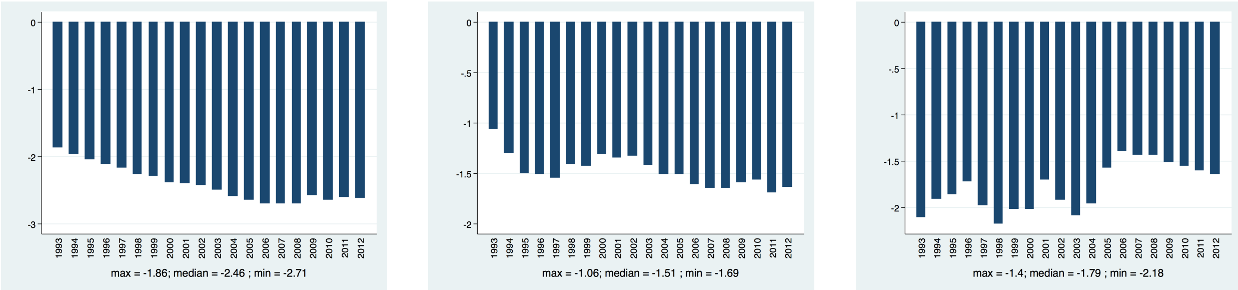
Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Rwanda, Romania, Russia, Sao Tome & Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, St. Kitts & Nevis, St. Lucia, St. Vincent & the Grenadines, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syria, Tajikistan, Tanzania, Thailand, Togo, Trinidad & Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Kingdom, United States of America, Uruguay, United Arab Emirates, Uzbekistan, Venezuela, Vietnam, Yemen, Zambia and Zimbabwe.

4B Estimated coefficients of the bilateral equation

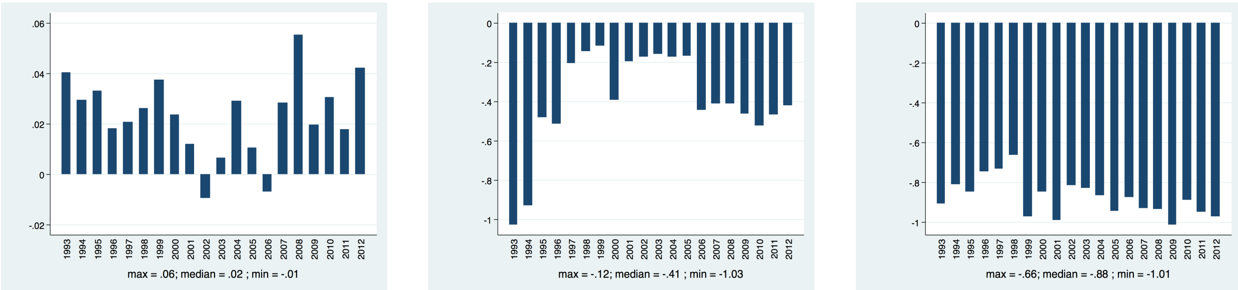
Table B1. Average estimates of bilateral equation, cont'd

Estimation:	OLS	FE	PPML	OLS	FE	PPML	OLS	FE	PPML
Dep. variable	Bilateral real trade share:			Bilateral migration share:			Bilateral FDI share:		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Interaction term of Border with:									
ln $Distance_{ij}$	0.197	0.359	0.342	0.771	0.099	1.194	-1.099	0.259	0.612
	(0.312)	(0.097)	(0.123)	(0.311)	(0.298)	(0.277)	(0.681)	(0.512)	(1.091)
	[0]	[2]	[0]	[8]	[0]	[15]	[5]	[2]	[6]
ln $Population_i$	-0.4632		-0.0163	-0.4625		-0.0399	0.4833		0.4671
	(0.0902)		(0.0578)	(0.4177)		(0.1207)	(0.4534)		(0.4518)
	[20]		[0]	[12]		[0]	[6]		[5]
ln $Population_j$	-0.085		0.000	-0.157		-0.304	0.365		-0.110
	(0.054)		(0.031)	(0.280)		(0.182)	(0.336)		(0.676)
	[0]		[0]	[2]		[3]	[2]		[5]
ln $Area_i$	0.701		0.252	0.174		-0.255	0.414		0.625
	(0.079)		(0.027)	(0.376)		(0.111)	(0.360)		(0.501)
	[20]		[20]	[3]		[1]	[6]		[7]
ln $Area_j$	0.350		0.309	0.149		0.179	0.855		0.707
	(0.069)		(0.074)	(0.249)		(0.245)	(0.359)		(0.897)
	[16]		[5]	[2]		[2]	[12]		[13]
$LL_i + LL_j$	1.221	0.425	0.593	0.418	0.273	-0.055	0.247	0.644	0.263
	(0.102)	(0.071)	(0.107)	(0.236)	(0.294)	(0.129)	(0.615)	(0.413)	(0.391)
	[20]	[17]	[20]	[9]	[4]	[0]	[6]	[10]	[2]
Common Official	1.591	-1.255	0.955	0.290	-0.357	1.048	3.168	-1.138	3.266
Language_{ij}	(0.166)	(0.132)	(0.107)	(0.373)	(0.323)	(0.509)	(1.373)	(0.395)	(1.292)
	[20]	[20]	[20]	[0]	[0]	[4]	[16]	[7]	[16]
Common	-1.758	-0.396	-1.077	-0.774	-0.176	-0.937	-2.851	-0.658	-3.230
Language_{ij}	(0.115)	(0.127)	(0.059)	(0.346)	(0.331)	(0.292)	(0.892)	(0.583)	(0.978)
	[20]	[0]	[20]	[4]	[0]	[3]	[16]	[5]	[18]
Time	-0.244	0.197	-0.317	-0.448	0.050	-0.324	-1.068	0.316	-1.110
Difference_{ij}	(0.036)	(0.026)	(0.074)	(0.388)	(0.202)	(0.290)	(0.498)	(0.456)	(0.602)
	[19]	[8]	[20]	[9]	[0]	[0]	[14]	[5]	[18]
Colony_{ij}	-1.767	-1.043	-1.659	-0.923	-0.885	-1.865	-1.232	-0.275	-3.180
	(0.527)	(0.084)	(0.572)	(1.628)	(0.307)	(0.605)	(1.076)	(0.546)	(2.117)
	[14]	[20]	[20]	[7]	[4]	[8]	[5]	[0]	[11]
Hegemon_i	0.425		1.211	1.150		1.622	-0.479		0.719
	(0.291)		(0.508)	(1.792)		(0.992)	(1.961)		(2.725)
	[0]		[16]	[8]		[6]	[2]		[7]
Hegemon_j	-0.022		1.284	-0.826		-0.667	-0.584		3.494
	(0.280)		(0.492)	(1.864)		(0.799)	(1.300)		(1.925
	[0]		[20]	[8]		[0]	[1]		[14]
Constant	-0.302	1.693	1.026	-7.195	-4.109	-5.210	9.982	-4.039	12.661
	(1.621)	(0.941)	(0.563)	(2.848)	(4.308)	(0.928)	(2.824)	(2.623)	(9.655
	[11]	[14]	[2]	[18]	[19]	[14]	[20]	[10]	[15]

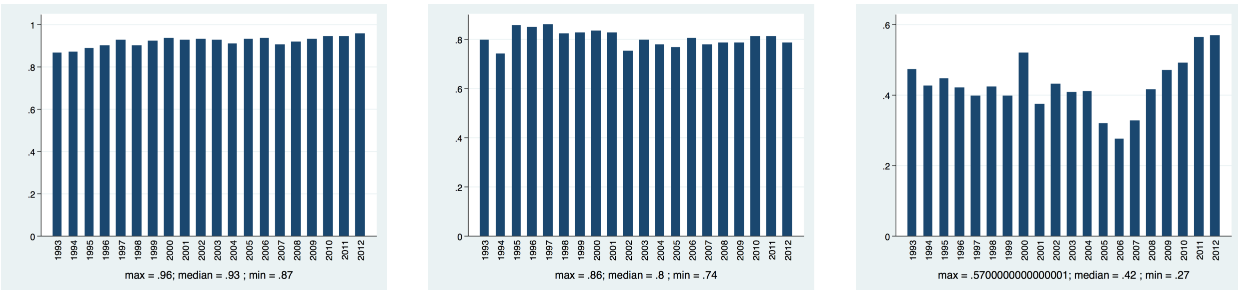
Notes: The table reports the average of the 20 coefficients estimated for each cross section of the data. The standard deviation of that average is reported in (round parentheses). The number in [square brackets] is the number of times (out of 20) that the estimated coefficient is significant at the 5% significance level. Column heading 'OLS' indicates that estimates for the bilateral equation without country fixed effects. Columns with 'FE' report estimates from the bilateral equation with country fixed effects estimated using OLS. While 'PPML' denotes the estimates using using Poisson Pseudo-Maximum Likelihood Method.



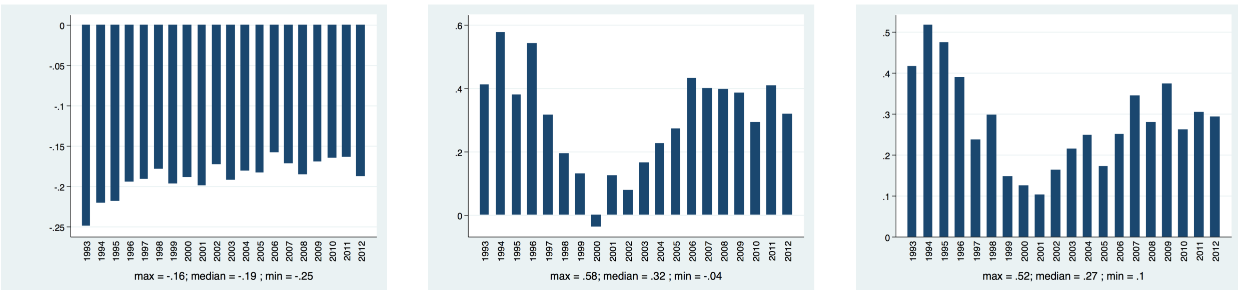
(a) $\ln Distance_{ij}$



(b) $\ln Population_{i}$

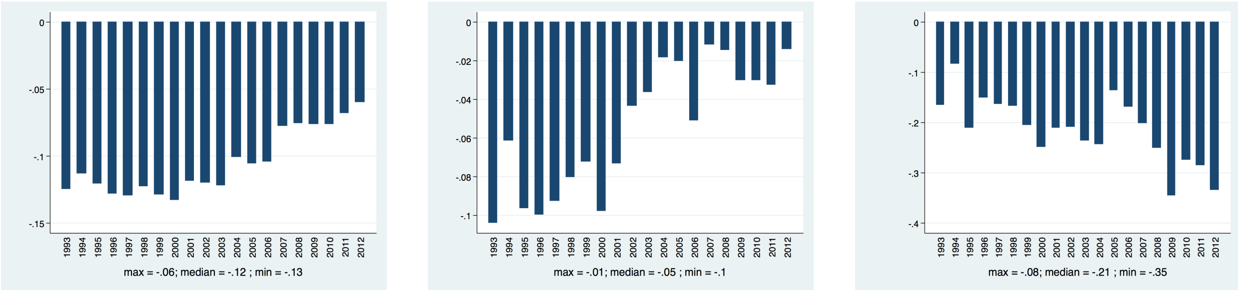


(c) $\ln Population_{j}$

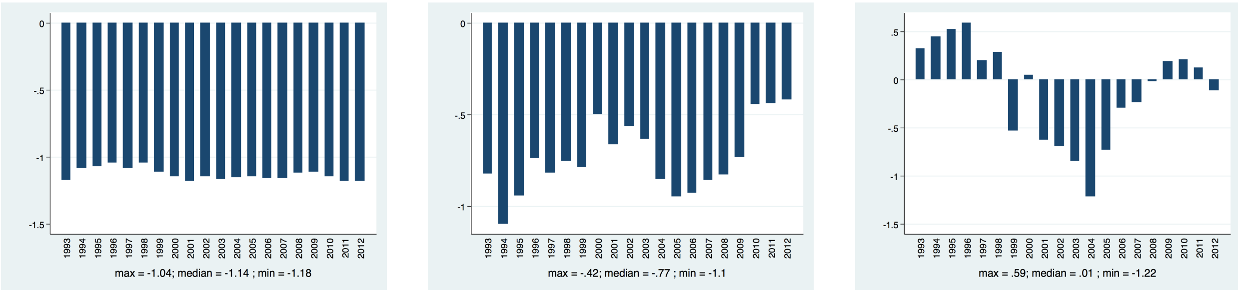


(d) $\ln Area_{i}$

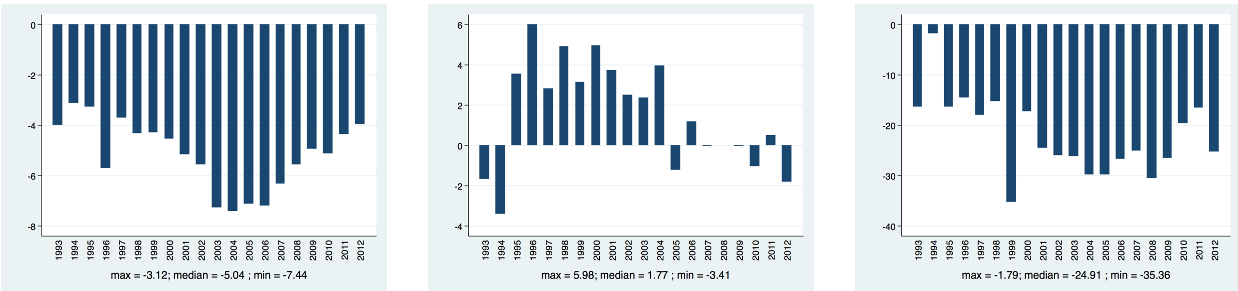
Figure B1. Bar charts depicting the size of the estimated coefficients from estimating the bilateral equation using OLS without country fixed effects on the dependent variables trade(lhs), migration(center), and FDI(rhs) for each year from 1993 to 2012.



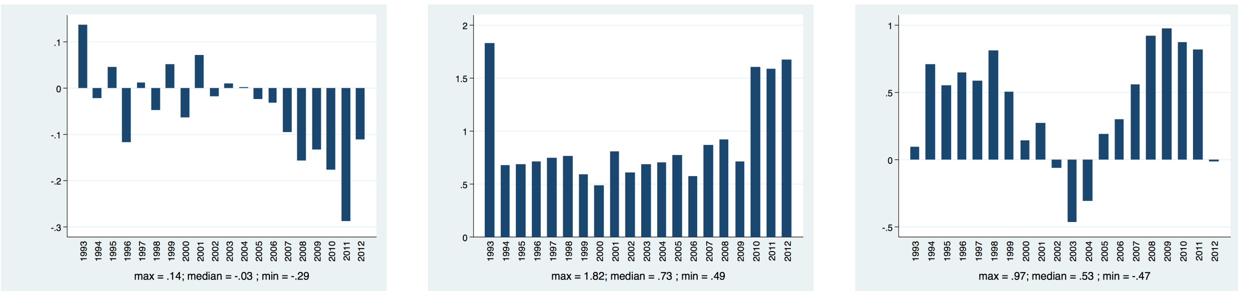
(a) $\ln Area_j$



(b) $Sum\ Landlocked_{ij}$

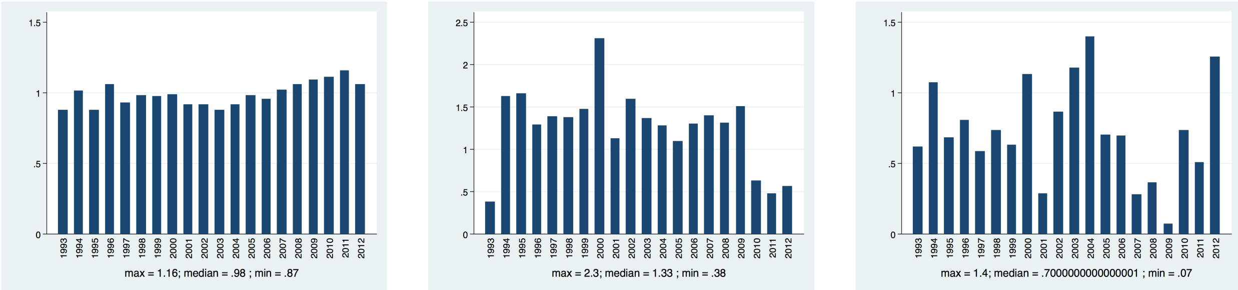


(c) $Border_{ij}$

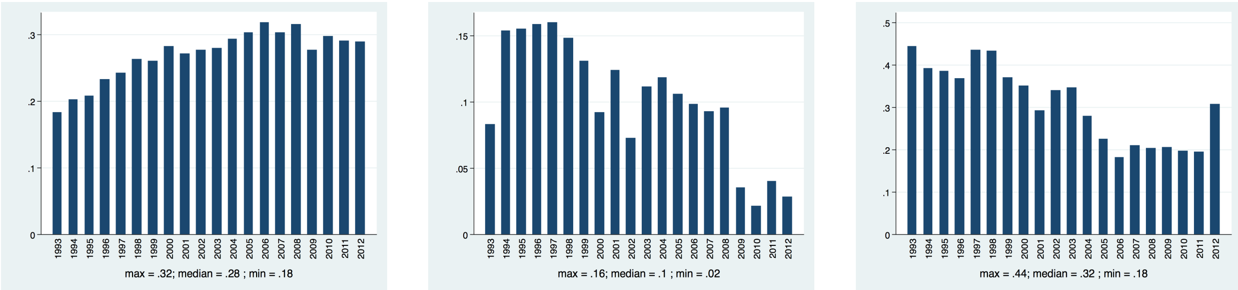


(d) $Official\ Common\ Language_{ij}$

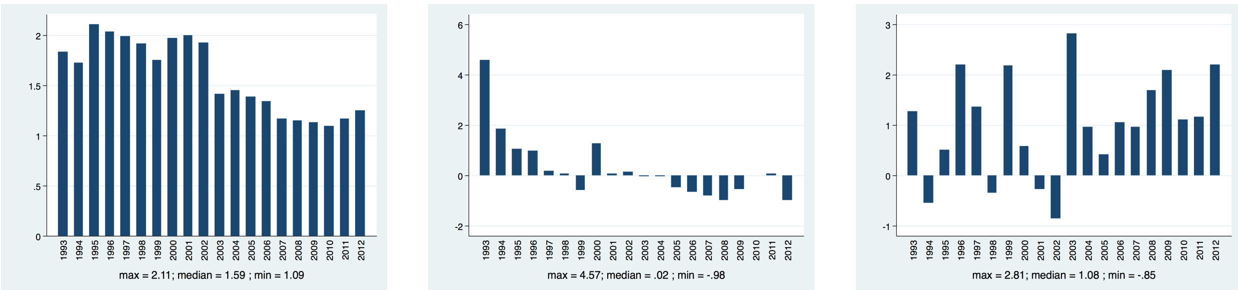
Figure B2. Bar charts depicting the values of the estimated coefficients from estimating the bilateral equation using OLS on the dependent variables trade(left), migration(center), and FDI(right) for each year from 1993 to 2012.



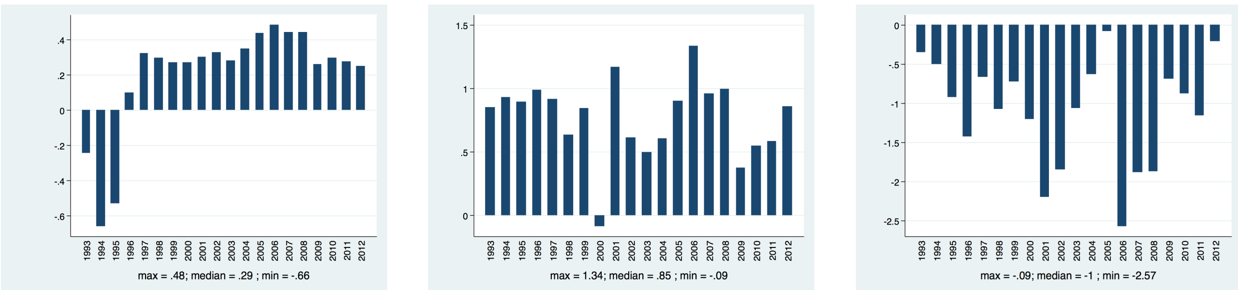
(a) *Common Ethnic Language*$_j$



(b) *Time Difference*$_{ij}$

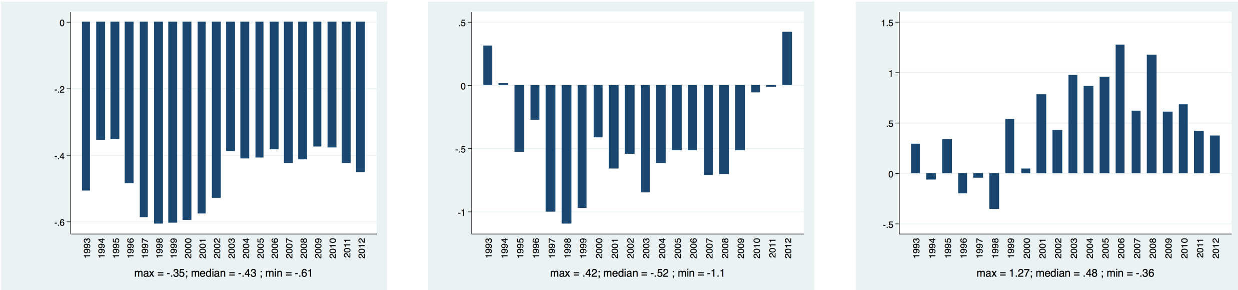


(c) *Colony*$_{ij}$

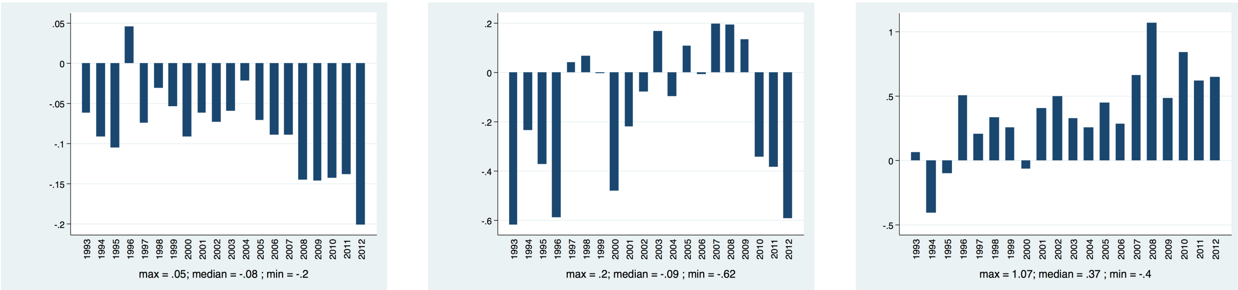


(d) $Border_{ij} \times \ln Distance_{ij}$

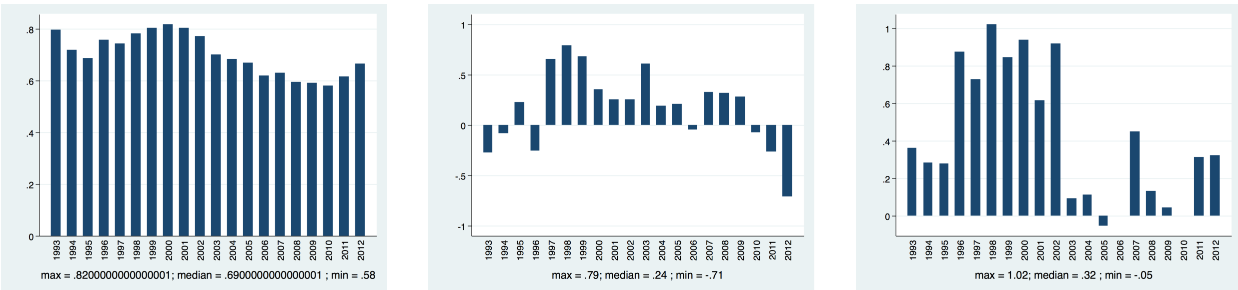
Figure B3. Bar charts depicting the values of the estimated coefficients from estimating the bilateral equation using OLS on the dependent variables trade(left), migration(center), and FDI(right) for each year from 1993 to 2012.



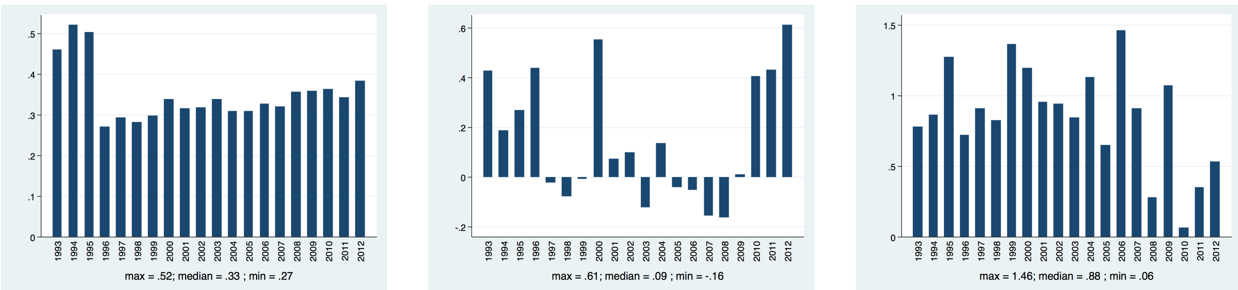
(a) $Border_{ij} \times \ln Population_i$



(b) $Border_{ij} \times \ln Population_j$

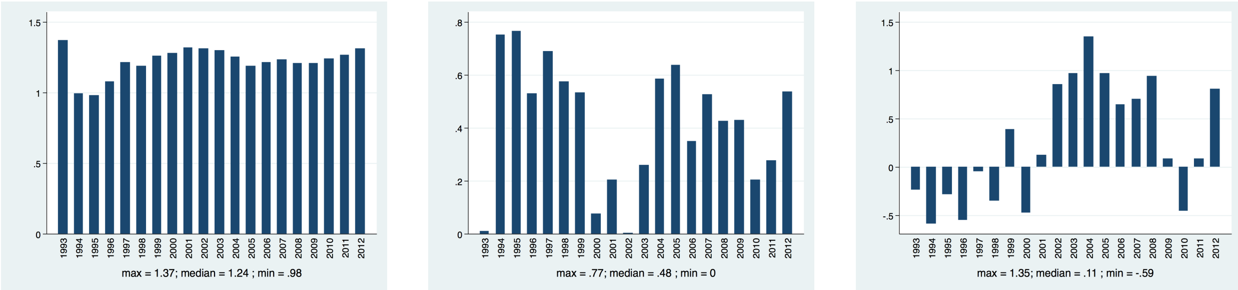


(c) $Border_{ij} \times \ln Area_i$

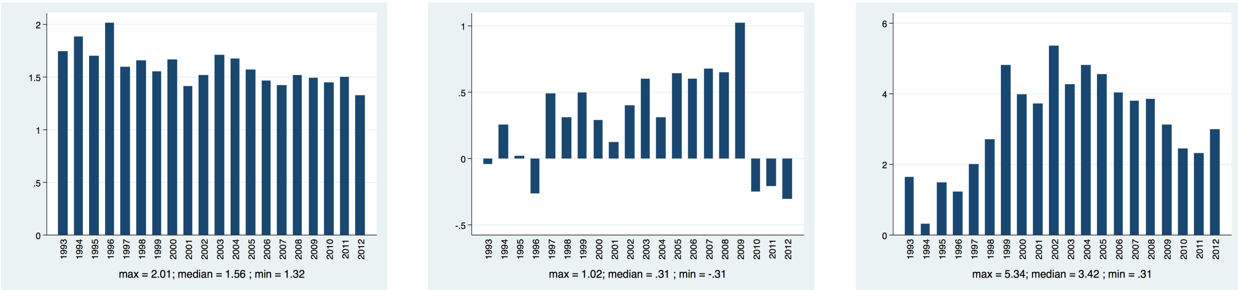


(d) $Border_{ij} \times \ln Area_j$

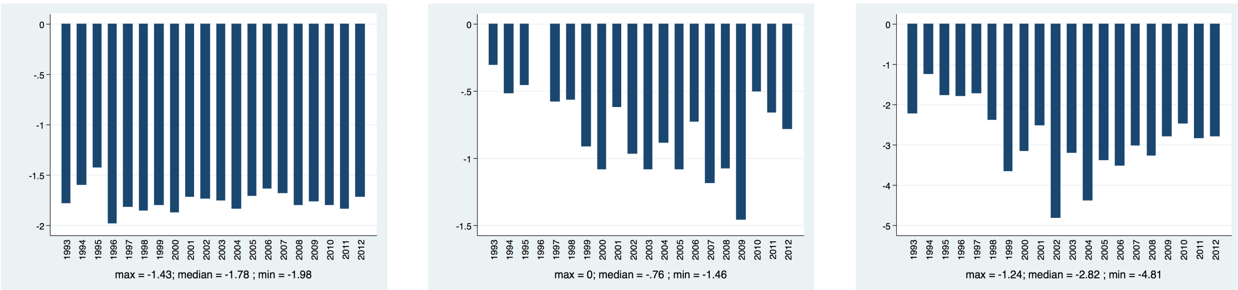
Figure B4. Bar charts depicting the size of the estimated coefficients from estimating the bilateral equation using OLS without country fixed effects on the dependent variables trade(lhs), migration(center), and FDI(rhs) for each year from 1993 to 2012.



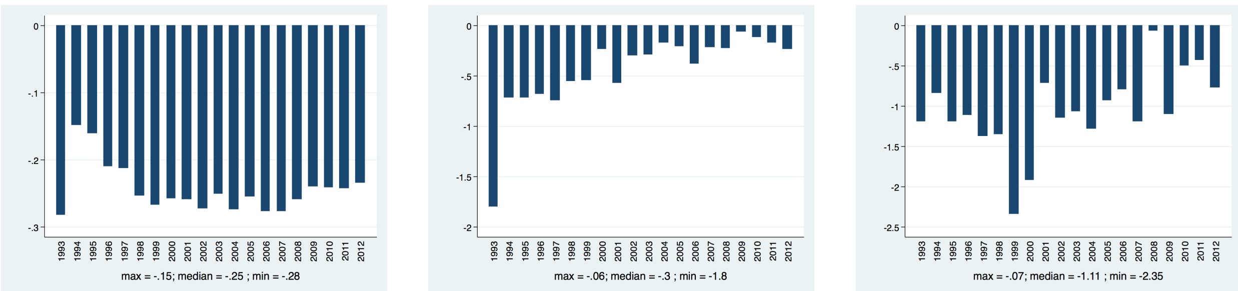
(a) *Border*$_{ij}$ × *Sum Landlocked*$_{ij}$



(b) *Border*$_{ij}$ × *Official Common Language*$_{ij}$

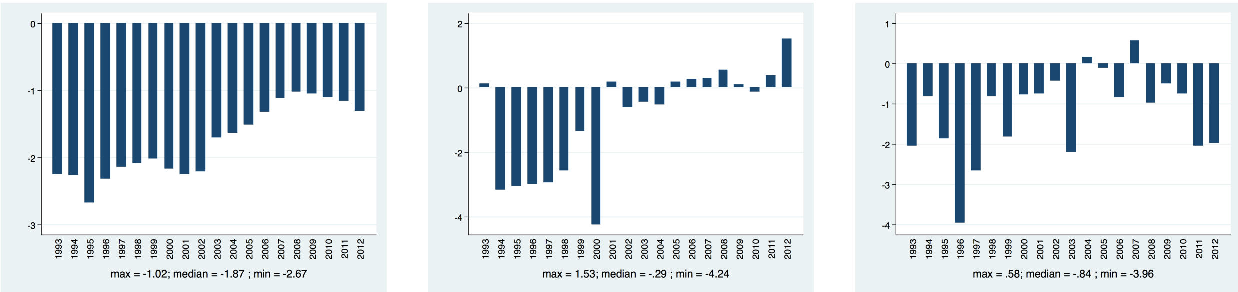


(c) *Border*$_{ij}$ × *Common Ethnic Language*$_{j}$



(d) *Border*$_{ij}$ × *Time Difference*$_{ij}$

Figure B5. Bar charts depicting the values of the estimated coefficients from estimating the bilateral equation using OLS on the dependent variables trade(left), migration(center), and FDI(right) for each year from 1993 to 2012.

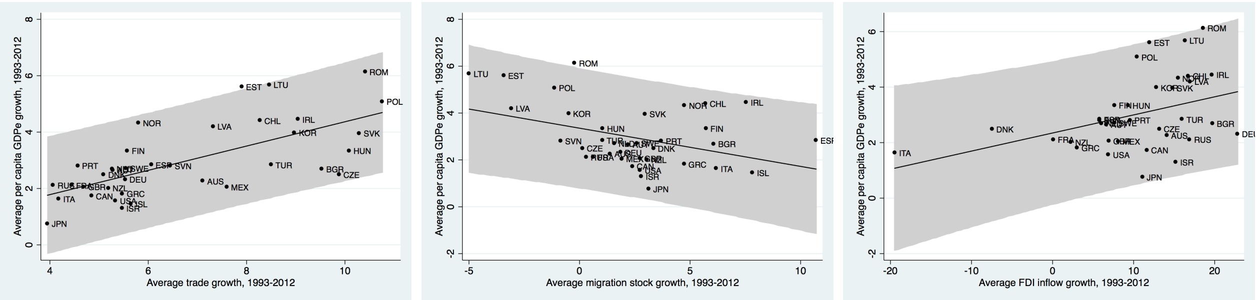


(a) $Border_{ij} \times Colony_{ij}$

Figure B6. Bar charts depicting the values of the estimated coefficients from estimating the bilateral equation using OLS on the dependent variables trade(left), migration(center), and FDI(right) for each year from 1993 to 2012.

4C Robustness of long difference analysis

As a robustness check I plot per capita GDP average growth on the average growth of trade, migration and FDI respectively in Figure C1. The figure includes a 95% confidence interval. This allows an for an examination whether individual countries in the sample are driving the results reported in columns 1, 5 and 6.



(a) **(b)** **(c)**

Figure C1. Average growth rates for per capita income set against average growth of trade, migration or FDI, respectively, over the period 1993-2012.

Panels a, b and c of Figure C1 support the reported trends in Table 4.3 columns 1, 5 and 6, respectively. Average trade growth is positively correlated with average per capita income growth (panel (a)), while in panel (b) average migration growth is negatively correlated with per capita income. Panel (c) shows that the relationship between average FDI growth and per capita income average growth is positive but not precisely estimated.

Figure C1 panel (c) identifies two countries that could be considered outliers in the sample, Italy (with average growth of -20% over the period) and Denmark (with an average growth of FDI of -7.5%). Excluding both countries from the analysis, however, does nothing to the general results reported in Table 4.3.

The size and significance of the coefficients for trade, migration and FDI when excluding Italy and Denmark are comparable to those when both countries are included. As before the coefficients for FDI in columns 3, 4, 6 and 7 in Table C1 are not significantly different from zero when Denmark and Italy are excluded. Furthermore, the inclusion of FDI as a control in columns 3 does little to change the size of the coefficient for trade compared to the coefficient for trade in column 1.

A second issue with this type of analysis is that FDI is volatile over time. The choice of start and end point of the analysis could influence the result. To test the robustness of the results to the choice of starting and end date, I calculate the log changes of per capita income, trade, migration and FDI first by changing the end date to 2011 (instead of 2012) and then changing the start date to 1994 as opposed to 1993. The results are presented below.

The results in Table C2 demonstrate that the results in Table 4.3 are not dependent on the choice of the end date. The size of the coefficients and their significance are in line with earlier results.

Changing the starting point of the period and calculating the log changes for the period 1994 to 2012, does have an effect on the significance of the coefficient for FDI when it is the only explanatory variable of the growth in per capita income (column 6). It continues to be

Table C1. Effect of real trade, migration and FDI growth on per capita income growth, 1993-2012 when excluding outliers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta \ln \mathit{Real\ trade}_i$	0.429***	0.394***	0.434***	0.390***			
	(0.085)	(0.081)	(0.090)	(0.085)			
$\Delta \ln \mathit{Migration}_i$		-0.094		-0.095	-0.154**		-0.165**
		(0.060)		(0.063)	(0.075)		(0.078)
$\Delta \ln \mathit{FDI}_i$			-0.005	0.003		0.026	0.036
			(0.020)	(0.018)		(0.041)	(0.033)
Constant	0.013	0.099	0.019	0.097	0.639***	0.511***	0.560***
	(0.101)	(0.103)	(0.102)	(0.104)	(0.052)	(0.089)	(0.079)
N	34	34	34	34	34	34	34
R^2	0.447	0.496	0.448	0.496	0.140	0.021	0.179

Notes: Dependent variable is the change in the log of per capita Expenditure-side Real GDP (at chained PPP's) over the period 1993-2012. Heteroskedastic robust errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Belgium, Luxembourg and Switzerland are excluded from the sample because of data availability. Italy and Denmark are the excluded outliers.

significant in column 7 when used with migration. However, the coefficient for FDI loses its significance when FDI is used to control for trade growth in columns 3 and 4 of Table C3.

In all three cases, the overall feature that the size of the coefficient for trade is adjusted downwards once one controls for migration but is unaffected by the inclusion of FDI as a control remains. This is not driven by the choice of countries nor by the choice of starting and end dates of the period across which the log change is calculated.

Table C2. Effect of real trade, migration and FDI growth on per capita income growth, 1993-2011

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta \ln \mathit{Real\ trade}_i$	0.383***	0.352***	0.385***	0.353***			
	(0.076)	(0.074)	(0.079)	(0.078)			
$\Delta \ln \mathit{Migration}_i$		-0.086		-0.086	-0.140**		-0.141*
		(0.056)		(0.057)	(0.069)		(0.071)
$\Delta \ln \mathit{FDI}_i$			-0.004	-0.001		0.010	0.012
			(0.021)	(0.017)		(0.031)	(0.023)
Constant	0.054	0.131	0.061	0.133	0.610***	0.527***	0.582***
	(0.088)	(0.094)	(0.091)	(0.095)	(0.046)	(0.071)	(0.065)
N	35	35	35	35	35	35	35
R^2	0.440	0.489	0.440	0.489	0.138	0.004	0.144

Notes: Dependent variable is the change in the log of per capita Expenditure-side Real GDP (at chained PPP's) over the period 1993-2012. Heteroskedastic robust errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Belgium, Japan, and Luxembourg are excluded from the sample because of data availability.

Table C3. Effect of real trade, migration and FDI growth on per capita income growth, 1994-2012

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta \ln \mathit{Real\ trade}_i$	0.438***	0.400***	0.435***	0.397***			
	(0.077)	(0.078)	(0.093)	(0.091)			
$\Delta \ln \mathit{Migration}_i$		-0.070		-0.070	-0.193**		-0.156*
		(0.067)		(0.068)	(0.090)		(0.081)
$\Delta \ln \mathit{FDI}_i$			0.001	0.002		0.077***	0.063**
			(0.015)	(0.016)		(0.022)	(0.023)
Constant	-0.010	0.065	-0.009	0.067	0.615***	0.421***	0.505***
	(0.085)	(0.104)	(0.094)	(0.110)	(0.052)	(0.040)	(0.061)
N	36	36	36	36	36	36	36
R^2	0.533	0.553	0.533	0.553	0.181	0.186	0.299

Notes: Dependent variable is the change in the log of per capita Expenditure-side Real GDP (at chained PPP's) over the period 1993-2012. Heteroskedastic robust errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Belgium, Iceland and Luxembourg are excluded from the sample because of data availability.

4D Correlation matrix for the large sample

Table D1. Correlation coefficients of generated instruments and actual shares for the large sample

	(1)	(1A)	(1B)	(1C)	(2)	(2A)	(2B)	(2C)	(3)	(3A)	(3B)	(3C)
	RTSH$_i$	$\widehat{RTSH}_i^{OLS}$	$\widehat{RTSH}_i^{FE}$	$\widehat{RTSH}_i^{PPML}$	MSH$_i$	$\widehat{MSH}_i^{OLS}$	$\widehat{MSH}_i^{FE}$	$\widehat{MSH}_i^{PPML}$	FDIsh$_i$	$\widehat{FDIsh}_i^{OLS}$	$\widehat{FDIsh}_i^{FE}$	$\widehat{FDIsh}_i^{PPML}$
RTSH$_i$	1											
$\widehat{RTSH}_i^{OLS}$	0.374***	1										
	(0.000)											
$\widehat{RTSH}_i^{FE}$	0.535***	0.294***	1									
	(0.000)	(0.000)										
$\widehat{RTSH}_i^{PPML}$	0.579***	0.733***	0.240***	1								
	(0.000)	(0.000)	(0.000)									
$\widehat{MSH}_i$	0.384***	0.287***	0.139***	0.500***	1							
	(0.000)	(0.000)	(0.000)	(0.000)								
$\widehat{MSH}_i^{OLS}$	0.419***	0.550***	0.144***	0.786***	0.373***	1						
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)							
$\widehat{MSH}_i^{FE}$	0.362***	0.220***	0.302***	0.402***	0.689***	0.366***	1					
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)						
$\widehat{MSH}_i^{PPML}$	0.556***	0.740***	0.239***	0.889***	0.579***	0.827***	0.398***	1				
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)					
$\widehat{FDIsh}_i$	0.207***	0.211***	0.0609**	0.278***	0.0316	0.218***	0.0552**	0.221***	1			
	(0.000)	(0.000)	(0.013)	(0.000)	(0.198)	(0.000)	(0.025)	(0.000)				
$\widehat{FDIsh}_i^{OLS}$	0.288***	0.173***	-0.0127	0.546***	0.145***	0.683***	0.289***	0.419***	0.184***	1		
	(0.000)	(0.000)	(0.607)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
$\widehat{FDIsh}_i^{FE}$	0.0396	0.0320	0.0201	0.154***	0.00871	0.152***	0.0318	0.0838***	0.0376	0.169***	1	
	(0.107)	(0.193)	(0.415)	(0.000)	(0.723)	(0.000)	(0.196)	(0.001)	(0.126)	(0.000)		
$\widehat{FDIsh}_i^{PPML}$	0.329***	0.494***	0.262***	0.518***	0.226***	0.550***	0.321***	0.468***	0.224***	0.472***	0.140***	1
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
N	1655											

Notes: Standard errors reported in parentheses. The instruments are generated using estimated coefficients from the adapted bilateral equation as shown in (4.2). FE indicates that country fixed effects are included in the estimation as well as prediction prediction. The superscript PPML indicates that estimates are from estimating the bilateral equation using Poisson Pseudo-Maximum Likelihood Method.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4E Results from Cross-Sections

Table E1. Estimates of the Income Regression using additional geographic controls and cross section, 2001

	(1)	(2)		(3)		(4)			(5)	(6)		(7)
Panel A: Second-stage regressions (selected results):												
$RTSH_i$	1.653	2.753		0.671		0.070						
	(1.502)	(11.737)		(1.611)		(1.907)						
MSH_i		-3.402				4.075			4.319**	4.292**		
		(33.352)				(5.570)			(1.981)	(2.138)		
$FDIsh_i$				17.325		4.677				2.741		-4.860
				(30.419)		(34.848)				(41.533)		(40.166)
N	125	125		125		125			125	125		125
Country FE	No	No		No		No			No	No		No
Time FE	Yes	Yes		Yes		Yes			Yes	Yes		Yes
Geo. controls	Yes	Yes		Yes		Yes			Yes	Yes		Yes
RMSE	0.614	0.827		0.809		0.611			0.610	0.610		0.671
Panel B: First-stage regressions (selected results):												
	$RTSH_i$	$RTSH_i$	MSH_i	$RTSH_i$	$FDIsh_i$	$RTSH_i$	MSH_i	$FDIsh_i$	MSH_i	MSH_i	$FDIsh_i$	$FDIsh_i$
$\widehat{RTSH}_i$	0.493*	0.053	-0.001	0.474*	0.029	0.073	-0.016	0.030				
	(0.278)	(0.263)	(0.090)	(0.283)	(0.031)	(0.249)	(0.076)	(0.034)				
$\widehat{MSH}_i$		9.305***	3.386***			8.739***	3.818***	-0.022	3.384***	3.756***	0.092	
		(2.370)	(1.164)			(2.369)	(0.814)	(0.287)	(1.095)	(0.806)	(0.271)	
$\widehat{FDIsh}_i$				0.741	-0.025	0.243	-0.185	-0.024		-0.183	-0.029	-0.023
				(0.521)	(0.047)	(0.319)	(0.168)	(0.051)		(0.170)	(0.051)	(0.050)
F-statistic	3.149	8.910	4.745	2.605	0.533	6.511	8.936	0.349	9.547	12.28	0.172	0.212
Partial R^2	0.0248	0.124	0.122	0.0506	0.00626	0.127	0.132	0.00629	0.122	0.132	0.00206	0.00146
SW F-stat	3.149	0.0174	0.0174	7.885	1.170	1.292	1.674	0.958	9.547	0.922	0.237	0.212
	[0.079]	[0.895]	[0.895]	[0.037]	[0.282]	[0.258]	[0.016]	[0.331]	[0.003]	[0.339]	[0.612]	[0.646]
AP F-stat	3.149	0.0439	0.0479	4.444	0.999	4.628	6.064	0.952	9.547	12.02	0.258	0.212
	[0.079]	[0.834]	[0.827]	[0.006]	[0.320]	[0.034]	[0.199]	[0.330]	[0.003]	[0.001]	[0.627]	[0.646]
Panel C:Reduced form (selected results):												
$\widehat{RTSH}_i$	0.816	0.149		0.814		0.078						
	(0.670)	(1.018)		(0.675)		(1.113)						
$\widehat{MSH}_i$		14.095				16.072*			14.615	16.371**		
		(9.920)				(9.106)			(9.178)	(8.159)		
$\widehat{FDIsh}_i$				0.066		-0.850				-0.863		0.113
				(1.130)		(1.454)				(1.436)		(1.066)
R^2	0.734	0.742		0.734		0.744			0.742	0.744		0.731

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The dependent variable in panel A and C is the log of Real GDP_i. All specifications include $\ln Population_i$ and $\ln Area_i$ and a constant. Geographic controls are Distance to the Equator, Percentage of land in the tropics, distance of the i's centroid to the coast, dummy equal to 1 if i is landlocked, dummy equal to 1 if i is in Latin-America, a dummy equal to 1 if i is either Australia, Canada, New Zealand or the United States, dummy equal to 1 if i is a (former) British colonly, dummy equal to 1 if i is a (former) French colony, climate indexes of average temperature and humidity as well as soil quality, dummy equal to 1 if there is an incidence of yellow fever, an index for presence of malaria in 1994, and a measure of oil reserves. F-stat is the first stage F-statistic of excluded instruments. SW F-stat refers to the Sanderson and Windmeijer (2016) multivariate F-statistic of excluded instruments, an improved version of the Angrist and Pischke (2009) F-statistic, labeled AP F-stat in this table. The null hypothesis of these tests is that the endogenous regressor is unidentified. The associated p-values of both tests is reported in [square brackets]. In case of only one endogenous regressor both the SW F-stat and AP F-stat are equal to the F-statistic of excluded instruments. Partial R^2 refers to the squared partial correlation corresponding to the SW F-statistic.

Table E2. Estimates of the Income Regression using additional geographic controls and cross section, 2005

	(1)	(2)		(3)		(4)			(5)	(6)		(7)
Panel A: Second-stage regressions (selected results):												
$RTSH_i$	1.525***	1.148		1.876		1.107						
	(0.506)	(1.071)		(2.711)		(4.878)						
MSH_i		2.089				2.116			5.395***	3.493		
		(3.733)				(6.029)			(1.914)	(2.958)		
$FDIsh_i$				-4.866		0.500				10.466		15.191*
				(33.579)		(47.941)				(9.246)		(9.044)
N	127	127		127		127			127	127		127
Country FE	No	No		No		No			No	No		No
Time FE	Yes	Yes		Yes		Yes			Yes	Yes		Yes
Geo. controls	Yes	Yes		Yes		Yes			Yes	Yes		Yes
RMSE	0.576	0.519		0.585		0.523			0.614	0.733		0.915
Panel B: First-stage regressions (selected results):												
	$RTSH_i$	$RTSH_i$	MSH_i	$RTSH_i$	$FDIsh_i$	$RTSH_i$	MSH_i	$FDIsh_i$	MSH_i	MSH_i	$FDIsh_i$	$FDIsh_i$
$\widehat{RealTSH_i}$	0.741***	0.440**	-0.019	0.560**	0.031	0.389*	0.012	0.026				
	(0.257)	(0.218)	(0.052)	(0.281)	(0.033)	(0.224)	(0.066)	(0.030)				
$\widehat{MSH_i}$		6.557**	3.328***			5.778*	3.794***	0.184	3.213***	3.844***	0.293	
		(2.865)	(1.034)			(3.356)	(0.917)	(0.500)	(0.833)	(0.830)	(0.497)	
$\widehat{FDIsh_i}$				1.251*	0.154	0.603	-0.361	0.133		-0.348	0.160	0.208***
				(0.723)	(0.105)	(0.874)	(0.276)	(0.136)		(0.248)	(0.121)	(0.068)
F-statistic	8.284	8.649	8.361	18.99	8.883	9.638	7.769	5.783	14.88	10.81	4.802	9.435
Partial R^2	0.105	0.149	0.143	0.123	0.0420	0.153	0.156	0.0435	0.143	0.156	0.0392	0.0348
SW F-statistic	8.284	4.606	4.685	0.236	0.214	0.169	0.228	0.145	14.88	5.862	6.786	9.435
	[0.005]	[0.034]	[0.033]	[0.423]	[0.607]	[0.682]	[0.634]	[0.704]	[0.0001]	[0.017]	[0.021]	[0.003]
AP F-stat	8.284	5.134	7.511	0.646	0.267	0.320	2.392	0.157	14.88	17.13	5.526	9.435
	[0.005]	[0.026]	[0.007]	[0.628]	[0.645]	[0.573]	[0.125]	[0.692]	[0.0001]	[0.000]	[0.011]	[0.003]
Panel C:Reduced form (selected results):												
$\widehat{RealTSH_i}$	1.129***	0.466		0.899*		0.469						
	(0.405)	(0.545)		(0.486)		(0.649)						
$\widehat{MSH_i}$		14.475				14.515*			17.334**	16.495**		
		(9.062)				(8.419)			(8.055)	(7.728)		
$\widehat{FDIsh_i}$				1.599		-0.030				0.462		3.167
				(2.111)		(2.361)				(2.171)		(2.044)
R^2	0.739	0.749		0.740		0.749			0.748	0.748		0.735

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, *p<0.10. The dependent variable in panel A and C is the log of Real GDP_i. All specifications include $\ln Population_i$ and $\ln Area_i$ and a constant. Geographic controls are Distance to the Equator, Percentage of land in the tropics, distance of the i's centroid to the coast, dummy equal to 1 if i is landlocked, dummy equal to 1 if i is in Latin-America, a dummy equal to 1 if i is either Australia, Canada, New Zealand or the United States, dummy equal to 1 if i is a (former) British colonly, dummy equal to 1 if i is a (former) French colony, climate indexes of average temperature and humidity as well as soil quality, dummy equal to 1 if there is an incidence of yellow fever, an index for presence of malaria in 1994, and a measure of oil reserves. F-stat is the first stage F-statistic of excluded instruments. SW F-stat refers to the Sanderson and Windmeijer (2016) multivariate F-statistic of excluded instruments, an improved version of the Angrist and Pischke (2009) F-statistic, labeled AP F-stat in this table. The null hypothesis of these tests is that the endogenous regressor is unidentified. The associated p-values of both tests is reported in [square brackets]. In case of only one endogenous regressor both the SW F-stat and AP F-stat are equal to the F-statistic of excluded instruments. Partial R^2 refers to the squared partial correlation corresponding to the SW F-statistic.

4F Using Feyrer approach to generate instruments

Methodological notes Feyrer (2009b)'s apprach to generating the instrument is using bilateral panel data to estimate the following:

$$\ln x_{ij} = \alpha + \beta_{seadistance,t} \ln seadistance_{ij} + \beta_{airdistance,t} \ln airdistance_{ij} + \gamma_i + \gamma_j + \gamma_t + \beta \mathbf{X}_{ij} + \epsilon \tag{F1}$$

where x_{ij} is either bilateral trade share, bilateral migration share or bilateral FDI share and sea distance is the distance between countries' capital cities when transporting goods by sea and air distance is the great-circle distance between the same two capitals. γ_i, γ_j and γ_t are fixed effects for country i, j and time respectively. As in Feyrer, I use a set of bilateral controls containing dummy variables equal to 1 if countries share a border, common official language, common ethnic language or colonial history as well as the time difference between country's capitals in hours, in essence following Ortega and Peri (2014)[14].

The resulting estimates are then used to predict the bilateral share for each country pair in the sample.

$$\widehat{x}_i = \sum_{j \neq i} e^{\widehat{\gamma}_i + \widehat{\gamma}_j + \widehat{\gamma}_t + \widehat{x}_{ij}} = \widehat{\gamma}_i + \widehat{\gamma}_t + \sum_{j \neq i} e^{\widehat{\gamma}_j + \widehat{x}_i j} \tag{F2}$$

where $\widehat{x}_i$ is the generated instrument for either trade, trade share, migration or migration share.

Like Feyrer, I include all the fixed effects when predicting the bilateral share and summing over all partners to generate the instrument. It is important to note that including country fixed effects when predicting bilateral trade, migration or FDI share would incorporate country specific characteristics that are endogenous to trade, migration and FDI into the generated instrument (OP). However, as Feyrer notes in a panel setting one can control for the identical characteristics by including country fixed effects in the income equation. These country fixed effects would replace country specific geographic controls that are required according to Rodriguez and Rodrik (2001). The inclusion of country fixed effects also enables the identification of trade's effect on income derived from changes over time (Feyrer, 2009b).

As before I need to ensure that the number of partner countries for which I am predicting bilateral trade share, migration share or FDI share is the same across all countries in my sample as well as over time. Therefore, I only include those partner countries for which there is at least one non-zero observation within the panel. This means that the number of partner countries can vary across the dependent variables of the bilateral equation, trade share, migration share or FDI share. This is no different from Ortega and Peri (2014) who, in order to maximize the number of observations used, estimates the bilateral trade equation using a smaller set of partners than when estimating the bilateral migration equation[15]

[14] The "bilateral" control sum landlocked is excluded from this set as it essentially a sum of two country-specific dummy variables each equal to one if the country is landlocked. Including the control as a covariate leads to a country dummy being omitted as a result of multicollinearity.

[15] Although not stated explicitly, the number of observations used in estimating the bilateral equation with the Poisson Pseudo-Likelihood Method for trade differs from the number of observations used for migration. This implies that for the same sample the number of partner countries differ. See columns 3 (for trade) and 6 (for migration) of Table 2 of Ortega and Peri (2014).

Table F1. Correlation coefficients of generated instruments and actual shares

	(1) RTSH_i	(1A) $\widehat{RTSH}_i^{FE1}$	(1B) $\widehat{RTSH}_i^{FE2}$	(2) MSH_i	(2A) $\widehat{MSH}_i^{FE1}$	(2B) $\widehat{MSH}_i^{FE2}$	(3) FDIsh_i	(3A) $\widehat{FDIsh}_i^{FE1}$	(3B) $\widehat{FDIsh}_i^{FE2}$
RTSH_i	1								
$\widehat{RTSH}_i^{FE1}$	0.647***	1							
	(0.000)								
$\widehat{RTSH}_i^{FE2}$	0.295***	0.118***	1						
	(0.000)	(0.002)							
MSH_i	0.233***	0.136***	0.107***	1					
	(0.000)	(0.000)	(0.006)						
$\widehat{MSH}_i^{FE1}$	0.242***	0.289***	0.180***	0.745***	1				
	(0.000)	(0.000)	(0.000)	(0.000)					
$\widehat{MSH}_i^{FE2}$	0.177***	0.112***	0.583***	0.138***	0.222***	1			
	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)				
FDIsh_i	0.294***	0.164***	0.133***	0.228***	0.207***	0.0476	1		
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.221)			
$\widehat{FDIsh}_i^{FE1}$	0.407***	0.294***	0.106***	0.365***	0.305***	0.0889**	0.531***	1	
	(0.000)	(0.000)	(0.006)	(0.000)	(0.000)	(0.022)	(0.000)		
$\widehat{FDIsh}_i^{FE2}$	0.0397	0.0300	0.213***	0.0507	0.0642*	0.267***	0.0187	0.0120	1
	(0.307)	(0.442)	(0.000)	(0.193)	(0.099)	(0.000)	(0.630)	(0.759)	
N	662								

Notes: Standard errors reported in parentheses. The instruments are generated using estimated coefficients from the adapted bilateral equation as shown in (F1) FE1 indicates that country fixed effects are included in the prediction while FE2 that country fixed effects are excluded. The superscript PPML indicates that estimates are from estimating the bilateral equation using Poisson Pseudo-Maximum Likelihood Method. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Data To estimate equation (F1) we add two additional variables to the data base described in section 4.4. The first is the variable sea distance from the CERDI database. It is the bilateral distance between the capital of two countries if goods are traveling by sea. This means that it is the road distance from each country's capital to either its largest port or the nearest port if the country is landlocked plus the sea distance between the two ports[16]. From the CEPII database we add the bilateral distance between capitals as a measure of air distance. This is not a populated weighted distance which is not concern given that the sea distance is a non weighted distance as well.

I drop Bulgaria, Lithuania, Latvia, Romania and Russia from the sample. When estimating (F1) for bilateral FDI-share as the dependent variable, the reporter country fixed effects for these countries are dropped from the estimation. Predicting bilateral FDI share for these countries means that the reporter country fixed effects are not incorporated into the generated instruments which introduces an ad hoc deviation from the generated instruments for other countries that were not dropped during the estimation. The drop of five countries from the sample accounts for the lower number of observations in Tables F1 and F2, 5 countries times 20 years.

[16]Given that for some country pairs there is no sea distance as the are both landlocked countries without a port, these observations are excluded when estimating the Feyrer version of the bilateral equation. Please note that in contrast to Feyrer I do not drop landlocked countries either as partners or reporters as the CERDI database allows me to construct a sea distance even for landlocked countries using the data on road distance provided.

Results As before Table F1 shows that including the estimates of the country fixed effects when predicting bilateral trade share before summing, increases the correlation coefficient between the instrument and the corresponding endogenous regressor (See columns 1, 2 and 3). The instrument that include the country fixed effects, denoted by superscript $FE1$, is highly correlated with the corresponding endogenous regressor. The correlation coefficients between the instrument and its corresponding endogenous regressor are higher than the correlation coefficients between each instrument and the other two instruments. For example in column 1 we see that the correlation coefficient between real trade share and its instrument, $\widehat{RTSH}_i^{FE1}$, is 0.65 while the correlation coefficient with $\widehat{MSH}_i^{FE1}$ and $\widehat{FDIsh}_i^{FE1}$ is 0.24 and 0.41, respectively. At the same time the correlation coefficients between the instrument and the other non-corresponding regressors are also lower than the correlation coefficient between the instrument and its corresponding endogenous regressor, column 1A shows that the instrument for trade is not highly corrlated with migration share nor with FDI share.

As I use the Feyrer instrument that includes country fixed effects in the prediction stage I only estimate seven specifications that contain both time and country fixed effects. Table F2 is the direct counterpart

References to Appendix

Bertoli, S., Goujon, M., Santoni, O., (2016). The CERDI-sea distance database, *Working Paper No. 2016/07*, Centre d'Études et de Recherches sur le Développement International (CERDI).

Feyrer, J. (2009b). Trade and Income - Exploiting Times Series in Geography, *Working Paper 14910*, National Bureau of Economic Research.

Mayer, T., Zignago, S., (2011). Notes on CEPII's Distances Measures: the GeoDist Database, *CEPII Working Papers 2011-25*, CEPII.

Ortega, F., Peri, G. (2014). Openness and income: The roles of trade and migration, *Journal of International Economics* **92**(2): 231-251.

Rodriguez, F. and Rodrik, D. (2001). Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence, *NBER Macroeconomics Annual 2000*, Vol. 15, MIT Press, pp. 261-338.

Table F2. Income regression using Feyrer instrument, 1993-2012

Panel A: Second-stage regressions (selected results):

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$RTSH_i$	0.069	0.261	-4.700	-10.739			
	(0.708)	(0.616)	(93.520)	(370.761)			
MSH_i		-1.712		-76.497	-3.984	-2.792	
		(6.500)		(2,552.617)	(3.308)	(3.490)	
$FDIsh_i$			-3.028	-12.324		-0.702	-0.483
			(50.570)	(399.489)		(0.701)	(0.486)
N	662	662	662	662	662	662	662
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: First-stage regressions (selected results):

	(1)	(2)	(2)	(3)	(3)	(4)	(4)	(4)	(5)	(6)	(6)	(7)
	$RTSH_i$	$RTSH_i$	MSH_i	$RTSH_i$	$FDIsh_i$	$RTSH_i$	MSH_i	$FDIsh_i$	MSH_i	MSH_i	$FDIsh_i$	$FDIsh_i$
$\widehat{RTSH}_i$	0.006	0.009	0.000	0.006	-0.009	0.008	0.000	-0.009				
	(0.019)	(0.018)	(0.001)	(0.019)	(0.010)	(0.017)	(0.001)	(0.010)				
$\widehat{MSH}_i$		-1.263**	0.142			-1.294**	0.140*	0.306	0.142	0.141*	0.284	
		(0.598)	(0.085)			(0.613)	(0.083)	(0.288)	(0.085)	(0.083)	(0.274)	
$\widehat{FDIsh}_i$				0.042	-0.079***	0.070*	0.003	-0.085***		0.003	-0.089***	-0.083***
				(0.064)	(0.015)	(0.041)	(0.007)	(0.014)		(0.007)	(0.012)	(0.014)
F-statistic	0.0975	2.805	1.403	0.229	26.71	3.777	0.965	42.99	2.805	1.449	59.09	36.33
Partial R^2	0.00197	0.0901	0.107	0.00410	0.0281	0.0958	0.108	0.0398	0.107	0.108	0.0289	0.0187
SW F-stat	0.0975	0.918	0.838	0.00443	0.00499	0.00373	0.00368	0.00383	2.805	5.778	271.1	36.33
	[0.757]	[0.345]	[0.150]	[0.949]	[0.449]	[0.968]	[0.953]	[0.812]	[0.103]	[0.0220]	[0.000]	[0.000]
Shea's Part. R^2	0.00197	0.00974	0.0116	2.87e-05	0.000197	7.67e-06	1.54e-05	1.16e-05	0.107	0.0898	0.0240	0.0187
AP F-stat	0.0975	0.514	2.169	0.00417	0.587	0.00161	0.00350	0.0576	2.805	4.533	152.9	36.33
	[0.757]	[0.478]	[0.367]	[0.947]	[0.944]	[0.952]	[0.952]	[0.951]	[0.103]	[0.041]	[0.000]	[0.000]

Panel C:Reduced form (selected results):

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\widehat{RTSH}_i$	0.000	0.002	0.000	0.001			
	(0.004)	(0.004)	(0.004)	(0.004)			
$\widehat{MSH}_i$		-0.572*		-0.596*	-0.568*	-0.593*	
		(0.319)		(0.310)	(0.320)	(0.310)	
$\widehat{FDIsh}_i$			0.040	0.053		0.053	0.040
			(0.036)	(0.046)		(0.047)	(0.036)
R^2	0.966	0.968	0.967	0.968	0.968	0.968	0.967

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. The instruments used are generated by estimating equation (F1) and including country fixed effects when predicting. The dependent variable in panel A and C is the log of Real GDP_i. The dependent variable for each first stage regression is reported in the first row of panel B. All specifications include $\ln Population_i$ and $\ln Area_i$ and a constant. F-stat is the first stage F-statistic of excluded instruments. SW F-stat refers to the Sanderson and Windmeijer (2016) multivariate F-statistic of excluded instruments, an improved version of the Angrist and Pischke (2009) F-statistic, labelled AP F-stat in this table. The null hypothesis of these tests is that the endogenous regressor is unidentified. The associated p-values of both tests is reported in [square brackets]. In case of only one endogenous regressor both the SW F-stat and AP F-stat are equal to the F-statistic of excluded instruments. Partial R^2 refers to the squared partial correlation corresponding to the SW F-statistic.

Chapter 5

Conclusion

As in any other literature, finding valid and strong instruments to investigate relationships between income and trade is a major challenge. Since the publication of Frankel and Romer (1999), hence FR, the literature has made extensive use of this instrumentation strategy.

These three chapters further explore the instrument's workings and contribute to the literature by showing that well reasoned methodological choices in instrument construction and use can inadvertently have far-reaching consequences for the validity of the instrument and result in inconsistent and biased estimates.

5.1 Summary of findings

Chapter 2 provides insights into how the make-up of the covariates used to generate the instrument for trade influence the estimate for trade in the income regression used by FR. Overall, the results are robust to the specification used. Dropping singular estimates or border interaction terms did little to change the result that trade has a positive effect on income. Neither did dropping a whole host of covariates.

Unexpectedly, singular covariates led to significant and plausible results in 6 out of 7 instances. Furthermore, the one covariate that generates a weak instrument and insignificant estimate of trade in the income regression, is bilateral distance, the covariate that intuitively lies at the heart of the gravity model for trade. Also empirically the literature has found that the negative effect of bilateral distance on bilateral trade is persistent over time (Disdier and Head, 2008). It is exactly this feature of the gravity model that is often used to identify the exogenous variation of trade as used by Feyrer (2009) and Pascali (2017) and migration as in Peri (2012) and Ortega and Peri (2014).

This contradiction between the findings of chapter 2 and the theoretical and intuitive motivation for the use of the FR instrument, leads to the analysis and findings in chapter 3. Using a Monte Carlo style analysis we generate two instruments with random geographic data; one instrument is predicted trade across actual trade partners, the other is predicted trade across all possible partners. We find that the decision to exclude predictions for non-trading partners leads to a consistent result that trade is a positive and significant determinant of income. Despite this instrument not containing any information on a country's geography it is still able to identify the relationship; its counterpart where bilateral trade is predicted for *all* possible trading partners does not. We subsequently show that when predicting bilateral trade and summing only across actual partners the instrument for trade will capture the number of partners and that it is this variation that causes the 2SLS estimates for trade to be consistently robust. It is also the most likely cause for the findings to be robust for those instruments generated using a singular covariate in the bilateral trade equation (in chapter 2).

This is problematic because the number of partners is not just highly correlated with a country's income, it is also endogenous to income as illustrated by the literature. Higher income countries have more developed infrastructure, institutions and better business environment than their poorer counterparts. This lowers the cost of cross-border trade for individual firms in high income countries allowing them to trade with more countries (Djankov et al., 2002). Chapter 3 therefore concludes that by summing predicted trade only across actual trading partners as opposed to all trading partners, the generated instrument is endogenous to income and therefore invalid as an instrument for trade in the income equation. The instrument when generated using predictions for all possible partners, continues to be a valid instrument for trade.

Chapter 4 finds that trade's effect on income is adjusted downwards when controlling for migration. This is not the case when controlling for FDI. At the same time, however, the estimates are not consistent in sign and significance. I can therefore not draw any reliable conclusions regarding the size of each determinant's effect on income or regarding their relative importance.

The results highlight the limitations of the data used and of the methodology employed.

Due to limited data availability of bilateral FDI and bilateral migration, the panel only covered a short time span. As a consequence this did not allow for enough within country variation over time to identify each of the determinants of income.

The methodological limitations are twofold. First, the estimates from regressing the bilateral trade equation do not generate enough variation across the three globalization flows, bilateral trade, migration and FDI openness. Secondly, and more fundamentally, is the issue that each of the instruments generated in this way makes use of the same variation of the covariates. Even in instances where individual effects can be identified, one cannot interpret the estimates in the traditional sense. As a result, one cannot make definitive statements on the relative importance of trade versus migration versus FDI for income.

5.2 Considerations for future research

The thesis contributes to the understanding of the FR instrument as well as providing two considerations for the use of generated instruments in general.

The first consideration drawn from the research emphasizes the basics when using generated instrumental variables: the importance of clearly clarifying how the methodology employed ensures that the generated instrument is identifying the intended exogenous variation, i.e. does the motivation support choices made in the construction of the instrument.

Together the results in chapter 2 and 3 demonstrate that this applies to the choice of explanatory variables in the equation used to generate the instrumental variables as well as the prediction method employed in its construction. Something as inadvertent as the choice to sum predicted bilateral trade only across actual trading partners significantly alters the composition of the generated instrument so that it captures variation of trade that is endogenous to income. Subsequently, the generated instrument constructed in this fashion is an invalid instrument to use in the income equation because it biases the results.

The second general consideration for future research is demonstrated by the analysis in chapter 4. It illustrates the limitations to the use of the same instrumentation strategy, in this case the generated FR instrument, for several endogenous regressors in the equation of interest. The resulting estimates cannot be interpreted for the simple reason that the underlying instruments make use of the same variation of the explanatory covariates used to generate them.

Therefore, to understand the relative importance of trade, migration and FDI for income future research must look toward finding a set of instruments where each individual instrument is distinct. The underlying exogenous variation must be different for each instrument.

In conclusion, the thesis does not present any results that invalidate the use of the FR instrument. The results presented here show that this generated instrument for trade is a strong instrument. However, the thesis does caution researchers that future research using FR instrument ensures and clarifies that the instrument is generated using a fixed number of trading partners for all countries in the sample as well as over time in a panel analysis. At the same time it advocates against using similar instruments when estimating equations with multiple endogenous regressors.

References

Disdier, A.-C. and Head, K. (2008). The Puzzling Persistence of the Distance Effect on Bilateral Trade, *Review of Economics and Statistics* **90**(1): 37–48.

Djankov, S., La Porta, R., Lopez-De-Silanes, F. and Shleifer, A. (2002). The Regulation of Entry, *Quarterly Journal of Economics* **117**(1): 1–37.

Feyrer, J. (2009). Trade and Income – Exploiting Time Series in Geography, *Working Paper 14910*, National Bureau of Economic Research.

Frankel, J. A. and Romer, D. (1999). Does Trade Cause Growth?, *American Economic Review* **89**(3): 379–399.

Ortega, F. and Peri, G. (2014). Openness and income: The roles of trade and migration, *Journal of International Economics* **92**(2): 231–251.

Pascali, L. (2017). The Wind of Change: Maritime Technology, Trade, and Economic Development, *American Economic Review* **107**(9): 2821–2854.

Peri, G. (2012). The Effect Of Immigration On Productivity: Evidence From U.S. States, *Review of Economics and Statistics* **94**(1): 348–358.