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One good turn deserves another? Evidence from China trade and aid policy

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Abstract

In this paper we study the impact of China's foreign aid on exports. To do this, we use a sample of 159 countries during the period 2000-2014 and employ a gravity model with GDP-weighted multilateral resistance terms. We find that the return on Chinese exports of every dollar spent on foreign aid is around 0.194-0.4115, at aggregate level and at HS6 product level, of 0.00004$ on average, for the whole period. Our results also indicate that Chinese foreign aid initiates trade of new product varieties with foreign partners and strengthens the trade in goods that are already exchanged; foreign aid could also enhance trade in existing geographical markets. However, it does not help to create new market shares. Furthermore, it fosters a stronger South-South integration as it encourages mainly the trade relations with developing and emerging countries.

Keywords: Emerging donor, aid-trade nexus, trade margin
JEL classification: F35, P33

1 Introduction

Over the last two decades, China's development has been extremely fast: the ratio of China's international trade to GDP (either export or import) has grown from 0.2% to more than 10%;[1] GDP growth has averaged nearly 10 percent a year (World Bank, 2017).

[1] Authors' calculation based on data taken from World Bank.

Along with this development, China has a pro-active role in international aid to other countries. During the 2000-2014 period, Chinese government provided an aid of 273.6 billion US dollar,[2] this assistance concludes 140 countries and regions in Africa, Asia and the Pacific, Latin America and the Caribbean, Middle East and Central and Eastern Europe (Drehet et al., 2017). The aid concerns sectors as infrastructure, education, health etc (Figure 1), and takes the form of export credit, technical assistance, grants and loans (Global Chinese Official Finance Dataset v1.0, 2014).

Nevertheless China is still an emerging country and it belongs to the upper middle income group at the world level (World Bank, 2017). The country is also characterized by strong regional development disparities (Démurger, 2001). For example, there were 55 million poor people living in rural areas in 2015 (World Bank, 2017). And the funds that are spent to provide international assistance are not directly used in China's local economy (i.e. to enhance internal aid, to boost the poor rural regions' activities etc.). At the same time, China highlights that its foreign aid is unconditional, which is to provide the assistance without imposing any economic or political conditions.[3] Furthermore, China provide the foreign aid to "help recipient countries to strength their self-development capacity, enrich and improve their people's livelihood, and promote their economic growth and social progress"(China White Paper on Foreign aid).[4] Therefore, some externalities on the Chinese economy might be expected when the country provides foreign aid to other parts of the world. In particular, Chinese foreign aid can be expected to have positive effects on the country's exports and therefore on its international economic development: this line of analysis will be tackled further on in this paper.

Several studies demonstrate that international aid could promote trade between the donor and the recipient, when the former is a developed country (Wagner, 2003; Martinez-Zarzoso et al., 2009; Hühne et al., 2014). However little evidence is available for the case in which donors are emerging countries. Hence, we aim at filling the gap and investigating the case of an emerging country, China, as a foreign aid donor. Within this framework, the research questions we raise are the following: is Chinese unconditional foreign aid enhancing trade? which type of aid is the most efficient in terms of trade boosting? which sectors and countries that are the mostly impacted by the aid - trade nexus?

The aid-trade nexus could be explained through several channels. Firstly, the income effect is assumed to be the key channel: a development aid could rise the recipient government's revenue and further increase the domestic income level, which triggers a higher consumption and more imports. Secondly, apart from the debt forgiveness, the assistance could also be provided on infrastructure and productive capacity building. This kind of aid could support the trade openness, improve the trade environment and generate more trade, which called habit formation. Lastly, "goodwill" initiatives, which explained by Djajic et al. (2004) :this effect could "cause a shift in preferences of the recipient country in the following period", by the mean of a reduction of the trade barriers and the emergence of good trade relation between donors and recipients (Djajic et al., 2004 ; Hansen et al., 2014; Martinez-Zarzoso et al, undated).

Most of the studies on Chinese foreign aid are rather descriptive (Ali Zafar, 2007). Only few econometric studies are performed in relation to China's foreign aid : in general,

[2]data is from Global Chinese Official Finance Dataset.

[3]By contrary, conditionality means that aid is only given following conditions which have to be met by the recipient country, i.e. good governance and democracy (Liu et al., 2017).

[4]Available on http://www.gov.cn/english/official/2011-04/21/content_1849913.htm

they aim at investigating the effectiveness of the Chinese foreign aid on the recipients' economies (Dreher et al., 2017, Busse et al., 2016). For example, Dreher et al. (2017) find that Chinese aid increases recipients' economic growth and this aid does not harm the effectiveness of western assistance. Using a different database, Busse et al. (2016) find that China's foreign aid positively affects recipient countries' economic growth, but this impact is not always statistically significant. Moreover, these authors interpret this result by underlying that Chinese foreign aid might have (only) a political influence on the recipients' international (voting) decisions. As far as we know, only one study shows that China could have benefits from the foreign aid provided at international level (Liu et al., 2017).

Our paper contribution to the literature is four-fold: (i) it identifies key determinants of the huge increase in the Chinese exports that allowed the country to become the first world exporter in 2009 (Berger et al., 2011); (ii) it complements the scarce literature on emerging donors, putting the accent on the Chinese unconditional foreign aid - trade nexus. To do this, a large number of trading partners (159) and of foreign aid flows are considered, over the 2000-2014 period, in a panel framework; (iii) it shows that Chinese foreign aid does impact trade margins: product extensive and intensive margins are increasedgeographical intensive margins are also enhanced while the geographical extensive ones are not affected; (iv) it underlines the South-South relations: the results show that China's foreign aid has a stronger impact on the trade with developing and emerging countries than with other countries around the world.

The structure of this paper is as follows. In Section 2, we present the literature review. Section 3 discusses the methodology and describe the data. The baseline results are reported in Section 4 and Section 5 estimates the impact at product level. Section 6 provides evidence on extensive and intensive margins. Robustness is checked in Section 7. Section 8 concludes.

2 Literature review

At empirical level, the literature on the emerging donors is not very abundant. Dreher et al. (2011) develop a study on "new" donors using a database on the non-DAC (OECD Development Assistance Committee) countries that includes some emerging countries. Using a probit and tobit setting, based on AidData during 2001-2008 for 16 non-DAC countries, they conclude that non-DAC countries act differently with respect to traditional donors and their behavior is more diversified and careless concerning the recipients' need.

Several other empirical analysis focus on specific emerging donors and their aid allocation. Fuchs et al. (2013) investigate the motivation of India's aid allocation by applying a probit and OLS methodology on the Indian AidData during 2008-2010. Their finding is in line with Dreher et al. (2011) and demonstrates that commercial and political self-interests dominate India's aid policy. Moreover, they also find that India prefers to provide aid to adjacent countries in order to strengthen its regional power. Neumayer (2003) finds, using probit and OLS econometric approaches, that Arab countries provide international aid based on ethnic and religious similarities (i.e. Arab and Islamic countries are the main recipients) and on political considerations (i.e. voting in the UN General Assembly). In China's case, as noted earlier, most of the studies investigate the effectiveness of Chinese

aid on African countries' economic growth(Dreher et al., 2017; Busse et al., 2016 etc.).[5] Hence, overall, we can argue that most of the existent literature on emerging donors, and China in particular, is oriented towards understanding aid allocation.

At theoretical level, several models are developed. Brecher et al.(1982) consider a standard trade model that includes two countries and two commodities. Using the example of food foreign aid, they find that an "import subsidy" is more efficient than a "consumption subsidy" in inducing benefits to both the donor and the recipient. Djajic et al. (2004) build a two-country two-period model to examine the inter-temporal reaction of trade between donors and recipients, following the foreign aid provided by the former, at period 1. They conclude that the benefits for donors and recipients may change over time: during the first period, they show that foreign aid could transfer welfare from donor to recipient, then directly through the income effect and through terms of trade effect indirectly, in the second period, in the presence of habit formation and of a change of preferences in the recipient in favor of the donor, both the donor and the recipient could gain in terms of welfare.

Empirically the relation between trade and foreign aid is usually analyzed in the case of advanced countries acting as donors. These studies find a positive link between the donor's foreign aid and its exports to recipient (Wagner, 2003; Hühne et al., 2014;Felicitas Nowak et al., 2009; Martinez-Zarzoso et al., 2017; Hansen et al., 2014).

Wagner (2003) runs a pooled OLS and fixed effect model to analyze the relation between international aid and exports. His sample covers the OECD-DAC listed countries over the period 1970-1990. He finds that trade elasticity varies from 0.062 to 0.195 under different estimations. Furthermore, he also shows that every dollar spend on aid has a direct effect on trade that equals 35 cents. However the indirect effect is even higher and amounts 98 cents.

Hühne et al. (2014) use pooled regression to explain the impact of foreign aid on exports and import. They examine data from 1990 to 2010 and include all recipient and donor countries listed in the OECD-DAC's International Development Statistics. Their findings suggest that Aid for trade triggers a 3% raise of recipient's exports to donor, and a 5% increase of imports from the donor.

Little is said in general about the aid-trade link focus from the individual donors perspective (Nowak et al., 2009; Martinez-Zarzoso et al., undated; Hansen et al., 2014).

Nowak et al. (2009) analyze the case of Germany as donor. They employ a dataset that includes 77 countries in BMZ cooperation (Federal Ministry for Economic Cooperation and Development) between 1962 up to 2005 and investigate to what extent the official international development assistance promotes German exports. Using a ECM and DOLS/DFGLS methodology, they show that for a long-run the elasticity on aid-trade nexus is 0.15, while the elasticity of 0.06 for short-run. With the help of advanced method, they compute that every dollar spent in international assistance can lead to an increase of exports of 1.49-1.72 euro on average.

Another research on the case of Netherlands is put forward by Martinez-Zarzoso et al. (2017). The authors estimate both static and dynamic gravity model by using two-way fixed effect, GMM and PDOLS and data on 130 countries over the period 1973-2009. They conclude that in static terms, each dollar spent by Dutch government on foreign assistance increases about 0.29$ on exports. Furthermore, the elasticity of short run is 0.06 and 0.1 for the long run in dynamic model. Comparing with Germany, the effect of Dutch foreign aid is more moderate in terms of trade.

[5]This is due to the fact that most recipients are based in Africa (Dreher et al., 2017)

A similar result is obtained by Hansen et al. (2014) by using fixed effect and GMM. With a sample of Denmark and its 144 recipient countries for the period of 1981-2010, they find that every dollar spent on aid by Denmark, the return on exports is about 30 cent. Moreover, the long term elasticity of Danish bilateral aid is 0.075, therefore the short term elasticity is slightly smaller on 0.059.

Other empirical techniques have also been used to understand the link between foreign aid and trade. Some of the studies using them put forward different results. Osei et al. (2004) employ Granger causality tests to understand the causal relationship between bilateral foreign aid and trade. Using data on 4 European donors and 26 African recipients between 1969-1995, they split their sample into five sub-panels and find that there is no clear evidence that aid could increase trade.

As previously argued, the literature on the emerging donors trade development in relation to their foreign aid policy is limited. In particular, for China, few empirical analysis oriented towards understanding the aid-trade relation can be found.

Zhu et al. (2015) use FGLS on China's trading data with 15 recipients during 2005-2011 period. They conclude that China's foreign aid could help to decrease the trading cost in recipients, and the effect on import cost is stronger than exports. Xiong et al. (2014) use the data on 123 countries during 1994-2011 period to investigate if China's foreign trade could promote international trade. They apply a cointegration analysis and show that there is no link between China's foreign aid and trade. Nevertheless, their study, as the authors underline it as well, is based on a database that is incomplete.

Moreover, Liu et al. (2017) compare the aid from US and China in Africa. They use bilateral data over the time span 2003-2012 and cover 26 and 30 African economics in relation to U.S. and China, respectively. Based on a gravity model, they conclude that 1% increase of China's aid flow to Africa leads to a 0.05% rise of this country's exports towards African continent and this export return might not be immediate; moreover, 1% increase of American foreign aid in African countries triggers a rise of 0.07% on American export to African partners. On the import side, their results show that aid has a positive and significant impact on China's import from Africa and the current aid is not affected by the import from the previous period whereas American foreign aid on Africa has no statistically significance on American imports from Africa.

3 Methodology and Data

3.1 Methodology

We aim at investigating whether an emerging donor, as China, can enjoy a return in terms of exports in relation to the foreign aid it provides. In order to understand the possible link between foreign aid and export, for China, we employ a gravity model (Anderson et al., 2003). The gravity model is a standard setting in international economics, used to explain trade relations. In this framework, Anderson et al. (2003) introduce the multilateral resistance terms to solve the omitted variables bias. Hence the general gravity model, transposed in our case, can be written as:

$$X_{cjt} = \frac{Y_{ct}Y_{jt}}{Y_{wt}} * (\frac{t_{cjt}}{P_{ct}P_{jt}})^{1-\sigma}$$

where c stands for China, j denotes the trading partner and t is the time dimension. Y_{ct} and Y_{jt} denote the income in China and country j, respectively; Y_{wt} is the world nominal income; P_{ct} and P_{jt} are the price indices in China and country j respectively, seen as "multilateral resistance" terms; t_{cjt} is the trade cost between China and country j. In our case, trade costs are captured by:

$$t_{cjt} = \{DIS_{cj}, CON_{cj}, RTA_{cjt}\}$$

The first variable DIS_{cj} is the distance between China and trading partner j; CON_{cj} is the contiguity dummy variable (the dummy is 1 if China shares its border with trading partner j, otherwise it is 0.); RTA_{cjt} translates the presence of a regional trade agreement (the dummy is 1 if the trading partner j is member of a trade agreement with China, otherwise it is 0).[6]

Usual gravity controls are employed in the model: GDP per capita, population and distance, dummy variables capturing regional trade agreements (such as ASEAN or APEC) or common borders (Anderson et al., 2003). We augment the model by using exchange rates. This is done for two reasons: first, as China does not share the same currency with any other country, exchange rates, in a panel setting as ours, could bring in additional information (Martinez-Zarzoso et al., 2003) and this especially since no joint country-time fixed effects are considered;[7]second, exchange rates could influence the structural form of the gravity model through scale effects and incomplete pass-through (Anderson et al., 2013). In standard gravity models that suppose constant returns to scale and complete pass-through, the use of country-time fixed effects to control for multilateral resistance was supposed to absorb any exchange rate effects as underlined by Anderson et al. (2013). These authors show, however, that non-uniform scale elasticity and incomplete pass-through can open channels through which exchange rates have real effects on trade in goods.

We replace the trade cost factor in the standard gravity equation presented previously and then log-linearize the model. Hence, our baseline model becomes:

$$\begin{aligned} ln(X_{cjt}) = \beta_0 + \beta_1 ln(Y_{ct}) + \beta_2 ln(Y_{jt}) + \beta_3 ln(Pop_{jt}) + \beta_4 ln(Aid_{cjt}) + \beta_5 ln(ER_{cjt}) \\ + \beta_6 ln(DIS_{cj}) + \beta_7 CON_{cj} + \beta_8 RTA_{cj} + \gamma_t + \alpha_j + \varepsilon_{cjt} \end{aligned}$$

where $ln(.)$ denotes the natural logarithm;
X_{cjt} captures China's export to trading partner j at year t in current US dollars;
Y_{ct}, Y_{jt} is China and trading partner j's GDP per capita in US dollars at year t, which are used to proxy countries' income;
Pop_{jt} is the population in trading partner j;
Aid_{cjt} is the foreign aid from China to trading partner j at year t;
ER_{cjt} is the real exchange rate between China and country j at time t;
γ_t is time fixed effect, α_j is country fixed effect, ε_{cjt} is the error term.

Further on, in order to approximate the multilateral resistance (MR) indicators, we also use the method proposed by Baier et al,. (2009). These authors suggest applying a

[6]Some regions and countries (i.e. Hongkong China, Macau China and Singapore) might share the same language with China, as they are a small part in China's export, the result of this dummy is omitted. Moreover, China does not share the same currency with any other trading partner, this variable is ignored in this model.

[7]In our empirical analysis, due to the structure of our panel, we introduce, in turn, country fixed effects and time fixed effects, respectively.

first-order log-linear Taylor-series expansion to construct the MR terms. The advantages of this method over the traditional approach are the following: it authorizes time variations in the multilateral resistance(MR) terms, it allows dealing with the omitted variables with the third countries (without having to introduce country-year fixed effects) and it is based on a theoretically grounded gravity model. Specifically, we compute the following MR variables on distance (MR_DIS_{cjt}), contiguity (MR_CON_{cjt}) and regional trade agreement (MR_RTA_{cjt}), using a time-varying GDP-weighted average.

$$MR\_DIS_{cjt} = lnDIS_{cj} - \sum_{k=1}^{N} \theta_{ct} lnDIS_{ck} - \sum_{m=1}^{N} \theta_{jt} lnDIS_{jm} + \sum_{k=1}^{N} \sum_{m=1}^{N} \theta_{kt} \theta_m lnDIS_{km}$$

where $\theta_{ct} = Y_{ct}/Y_{wt}$ and $\theta_{ct} = Y_{jt}/Y_{wt}$; $lnDIS_{ck}$ denotes the logarithm of the distance from China to other countries; $lnDIS_{jk}$ denotes the logarithm of distance from trading partner j to other countries; $lnDIS_{km}$ denotes the logarithm of all distances for other countries.

$$MR\_CON_{cjt} = CON_{cj} - \sum_{k=1}^{N} \theta_{ct} lnCON_{ck} - \sum_{m=1}^{N} \theta_{jt} lnCON_{jm} + \sum_{k=1}^{N} \sum_{m=1}^{N} \theta_{kt} \theta_m lnCON_{km}$$

where $lnCON_{ck}$ denotes the contiguity between China and other countries; $lnCON_{jk}$ denotes the contiguity between trading partner j and other countries; $lnCON_{km}$ denotes the contiguity between other countries.

$$MR\_RTA_{cjt} = RTA_{cjt} - \sum_{k=1}^{N} \theta_{ct} lnRTA_{ck} - \sum_{m=1}^{N} \theta_{jt} lnRTA_{jm} + \sum_{k=1}^{N} \sum_{m=1}^{N} \theta_{kt} \theta_m lnRTA_{km}$$

where $lnRTA_{ckt}$ denotes the regional agreement between China and other countries at time t; $lnRTA_{jkt}$ denotes the regional agreement between trading partner j and other countries at time t; $lnRTA_{kmt}$ denotes the regional agreement between other countries at time t.

In order to include the MR tems described above, our MR baseline model will be written as follows:

$$\begin{aligned} ln(X_{cjt}) = \beta'_0 + \beta'_1 ln(Y_{ct}) + \beta'_2 ln(Y_{jt}) + \beta'_3 ln(Pop_{jt}) + \beta'_4 ln(Aid_{cjt}) + \beta'_5 ln(ER_{cjt}) \\ + \beta'_6 MR\_DIS_{cjt} + \beta'_7 MR\_CON_{cjt} + \beta'_8 MR\_RTA_{cjt} + \gamma'_t + \alpha'_j + \varepsilon'_{cjt} \end{aligned}$$

In these models (baseline and MR baseline), the variable of interest is foreign aid: if the foreign aid can increase export from China to recipient countries, the coefficient β_4 should be a positive one. Moreover, a higher income level in trading partner j can translate an increasing demand on the foreign market, and can thus positively impact trade. An increase of the development level in China could boost the productivity and hence the exports. Thus, β_1 and β_2 are expected to be both positive. Population is used, in the model, in order to capture the market size: β_3 can be positive. Distance can also impact trade: "commerce declines dramatically with the distance" (Leamer, 2007). In this case β_6 is expected to have a negative sign. In the same time, β_7 should be positive when China shares its border with the trading partners. Concerning the bilateral exchange rate, it captures a price effect: an appreciation of the Chinese yuan can reduce exports (β_5 is

negative in this case). If the partner country is member of a regional trade agreement such as ASEAN or APEC to which China belongs as well, the impact on trade (β_8) is supposed to be positive.

The empirical analysis is developed first using a pooled OLS regression on China's bilateral export and foreign aid. Then we include fixed effects (i.e. country specific effects and time effects).[8] When using the MR terms, we first apply a first-order Taylor expansion to the explanatory variables and then we use OLS and fixed effects.

3.2 Data

The above models are run on a dataset that covers 159 countries and the time span 2000-2014. Data on China's foreign aid is taken from Global Chinese Official Finance Dataset, using the nominal USD value of the amount specified for the project. China's bilateral export value (both in aggregate and HS6 product level) in US dollars is from BACI database. GDP per capita, population, distance, contiguity and regional agreement are gravity variables drawn from CEPII. Real exchange rate are calculated using consumer price index and nominal exchange rates obtained from BRUEGEL datasets. In order to improve the accuracy of bilateral exchange rate, we follow the strategy of Freund et al. (2011) to calculate bilateral real exchange rate: $BEER_{j,c} = NER_j/NER_c * CPI_c/CPI_j$, where $BEER_{j,c}$ denotes the bilateral effective exchange rate, NER_j is j partner's currency per US dollar and NER_c is the Chinese yuan per US dollar. CPI_c is the consumer price index in China and CPI_j is the consumer price index of trading partner j. A rise in the effective exchange rate implies an appreciation of Chinese yuan while a decrease translates a depreciation. In the robustness check, We also include some addition variables. Trade freedom index from Heritage Foundation. Data on FDI inflow and outflow is collected from United Nations Conference on Trade and Development Online database. Descriptive statistics are showed in Table 1.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
lnX	2,595	19.75722	2.770439	11.5453	26.70745
lnv	4,774,341	11.44825	2.564763	6.908755	24.47641
$ln(Y_{ct})$	2,595	7.874769	0.7043551	6.855597	8.946831
$ln(Y_{jt})$	2,595	8.248322	1.603973	4.682266	11.66662
$ln(Pop_{jt})$	2,595	1.679655	2.051727	-3.9542	7.166491
$ln(DIS_j)$	2,595	9.011148	0.5256678	7.06319	9.857974
$ln(ER_{jt})$	2,475	-0.0343658	0.2586203	-1.733703	1.061802
$ln(Aid_{jt})$	2,595	6.97669	8.662136	0	24.31498
$Tradefreedom$	2,325	70.55729	13.87136	0	95
$ln(FDI_{inflow})$	2,595	10.89672	7.485749	1	25.12102
$ln(FDI_{outflow})$	2,595	1.554871	1.233298	.6931472	6.848005

4 Baseline results

In this section we study the impact of China's unconditional foreign aid on trade at aggregate trade level. First, we present the benchmark results that capture the overall effect of aid-trade nexus. Then a dynamic framework is constructed to disentangle the

[8] A Hausman test has been run and allowed us to choose the fixed effects model against the random effects one.

endogeneity issue. Furthermore, the aid heterogeneity will be examined by analyzing the impact of different categories of aid (i.e. related to infrastructure, productive capacity, public welfare and other activities) on export at aggregate level.

4.1 Aggregate export level

The baseline results are presented in Table 2: the impact of China's foreign aid on aggregate export. These results suggest that Chinese foreign aid has a positive and significant impact on export. This is in line with what the literature finds, but in the case of developed countries acting as donors (see Wagner., 2003; Martinez-Zarzoso et al., 2009 etc). The first column reports the pooled OLS results with standard gravity variables: it shows that 1 dollar spent by Chinese government on foreign aid increases by 0.4115 dollars the value of export.[9] Column (2) presents the OLS results with MR terms and shows again a positive impact of Chinese foreign aid on trade. It can be seen that a dollar spent on foreign aid, increases by 0.354 dollar the Chinese export value.[10] The results obtained by controlling for country and year fixed effects are reported in Column (3). The coefficient suggests that one more dollar spent on foreign aid exerts an increases of 0.193 dollars on China's export.[11] Column (4) presents the country-year fixed effects estimation with MR variables, we find that one more dollar spent on foreign aid by Chinese government promote 0.194 dollar on export value.[12]

All the other control and gravity variables have the expected sign and are statistically significant overall. Firstly, an appreciation of Chinese yuan could exert a reduction of China's exports. Taken account of this information, one can underline the importance of price competitiveness effect of China's exports in relation to its trading partners. The GDP per capita both in China and in the trading partner positively affect bilateral trade. The coefficient of population is positive meaning that bigger markets import more. The distance among countries hinders trade. Furthermore, the dummies for contiguity and regional trade agreements(RTA) are both positive and statistically significant.

This "return" of Chinese international assistance, in terms of exports, seems to be much smaller, compared with the ones underlined by the empirical studies on donors that are developed countries. For example, Felicitas et al.(2008) find that the return on each euro spent by Germany on international aid is "in the range of EUR 1.49 to 1.72." In the case of emerging donors, as India, Fuchs et al.(2013) show that Indian exports grow by 1% if Indian foreign aid increases by 0.4%.

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[9]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.0128 * \frac{1.913e+13}{5.950e+11} = 0.4115.$

[10]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.011 * \frac{1.913e+13}{5.950e+11} = 0.354.$

[11]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.00601 * \frac{1.913e+13}{5.950e+11} = 0.193.$

[12]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.00605 * \frac{1.913e+13}{5.950e+11} = 0.194.$

Table 2: Baseline results

	(1) OLS	(2) OLS	(3) Country-Year FE	(4) Country-Year FE
lnY_{ct}	0.904***	1.881***		
	(0.0326)	(0.0899)		
lnY_{jt}	0.870***	0.923***	1.038***	1.036***
	(0.0188)	(0.0197)	(0.0714)	(0.0748)
lnP_j	0.954***	0.992***	1.104***	1.074***
	(0.0124)	(0.0134)	(0.12)	(0.121)
$lnER_{cjt}$	-0.152*	-0.311***	-0.380***	-0.384***
	(0.073)	(0.0718)	(0.0935)	(0.0943)
$lnAid_{cjt}$	0.0128***	0.0110***	0.00601***	0.00605***
	(0.00302)	(0.00305)	(0.00159)	(0.00159)
$lnDIS_{cj}$	-0.414***			
	(0.0439)			
CON	0.478***			
	(0.128)			
RTA	0.210***			
	(0.0573)			
Country FE	no	no	yes	yes
Year FE	no	no	yes	yes
MR terms control	no	yes	no	yes
N	2475	2475	2475	2475
adj. R-sq	0.841	0.843	0.973	0.973

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at time t

4.2 Endogeneity

Endogeneity has been tackled, so far, at least partially: the omitted variable concern has been taken care of by using country-time fixed effects. However, one may argue that, when analyzing the aid-trade relation, there might be a causality issue (Hühne et al., 2014; Osei et al., 2004; Martinez-Zarzoso et al., 2009). For example, foreign aid could trigger an increase in donors' exports, but causality may run also from exports to foreign aid: donors might condition aid by adding a special clause underlining that the provided funds should be used to buy goods or services from the donor (Wagner, 2003). However, this latter aspect does not really characterize our framework as China provides unconditional foreign aid.

We follow Hühne et al. (2014) and employ extended lags for the explanatory variables (one-year lag of aids, GDP per capita and exchange rates) in order to catch a dynamic dimension. The results confirm previous findings and are available in Table 3. They provide evidence that foreign aid in t-1 has a positive and statistically significant effect on exports in t. This outcome is also confirmed both by the theoretical literature (Djajic et al., 2004) and the empirical one (Hühne et al., 2013). The standard gravity model results of Pooled OLS are showed in Column (1): one dollar spent on foreign aid in t-1 increases bilateral exports by 0.41 dollars.[13] Column (2) shows the OLS results controlled with MR terms. It present China's exports increase by 0.35 dollar by spending a dollar on foreign assistance.[14] Furthermore, country-year fixed effects are introduced in Column (3) and Column (4). When standard gravity controls are includes - Column (3) -, a return of 0.09

[13]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.014 * \frac{1.913e+13}{5.950e+11} = 0.4115$.

[14]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} =$

Table 3: Results with one-year lag of explanatory variables

	(1) OLS	(2) OLS	(3) Country-Year FE	(4) Country-Year FE
lnY_{ct}	0.844***	1.931***		
	(0.0353)	(0.103)		
lnY_{jt}	0.856***	0.914***	0.772***	0.756***
	(0.0185)	(0.0198)	(0.0641)	(0.0684)
$lnPop_{jt}$	0.953***	0.995***	1.188***	1.151***
	(0.0129)	(0.014)	(0.134)	(0.135)
$lnER_{cjt}$	-0.115	-0.186***	0.0373	0.0319
	(0.0752)	(0.0719)	(0.0813)	(0.0817)
$lnAid_{cjt}$	0.0140***	0.0113***	0.00279*	0.00274*
	(0.00316)	(0.00324)	(0.00161)	(0.00161)
$lnDIS_{cj}$	-0.428***			
	(0.045)			
CON	0.452***			
	(0.134)			
RTA	0.216***			
	(0.0593)			
Country FE	no	no	yes	yes
Year FE	no	no	yes	yes
MR terms control	no	yes	no	yes
N	2309	2309	2302	2302
adj. R-sq	0.836	0.837	0.974	0.974

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports

dollar could be obtained in t, following every additional dollar spent on foreign aid in t-1.[15] In Column (4), while taking account of the MR terms, we show that one dollar that is used on aid increases by 0.088 dollar China's export to recipient countries.[16] These coefficients are smaller to the ones obtained with contemporaneous variables when using the fixed effect (in column (3) and (4)) empirical methodology. Therefore, the results with OLS (in column (1) and (2)) show a same elasticity. Those results are different to the outcome of Hühne et al. (2014), since his research is on the case of advanced donors. Concerning the other controls and gravity factors, the results hold and are overall significant.

4.3 Aid heterogeneity

To better understand the effects of aid on donor's export to recipient country, Hühne et al (2013) split the aiding sector into three (four) categories. We follow their classification and decompose China's foreign aid into four categories:[17] (i) Economic infrastructure ($Infra$ variable), including Communications, Energy generation and supply, Transport and storage, Other social infrastructure and services; (ii) Productive Capacity (Pro_cap variable)

$\beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.0113 * \frac{1.913e+13}{5.950e+11} = 0.3533.$

[15]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.00279 * \frac{1.913e+13}{5.950e+11} = 0.09.$

[16]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.00274 * \frac{1.913e+13}{5.950e+11} = 0.088.$

[17]For more information about aiding sectors, please see figure 1 in appendix. All the information about sectors are defined and provided by the database of Global Chinese Official Finance Dataset. The sectors are classified similarly to the Credit Reporting System.

consisting of Agriculture, forestry and fishing, Banking and financial services, Business and other services, Industry, mining, construction, Trade and tourism, Action relating to debt, Emergency response and General budget support; (iii) Public welfare (*Pub_wel*) consisting of Education, General budget support, General environment protection, Government and civil society, Health, Support to non-government organization and Women in development; (iiii) Other (*Other* variable) multi-sector and Unallocated/ unspecified. We consider, in turn, each type of aid in the standard log-linearized gravity model and asses its impact on trade, using country-year fixed effects. Results are as following (in table 4):

Table 4: Country-Year fixed effect for different aid categories

	(1) Infra	(2) Pro_cap	(3) Pub_wel	(4) Other
lnY_{jt}	1.027***	1.040***	1.042***	1.041***
	(0.0754)	(0.0754)	(0.0754)	(0.0753)
$lnPop_{jt}$	1.068***	1.092***	1.085***	1.089***
	(0.121)	(0.122)	(0.122)	(0.122)
$lnER_{cjt}$	-0.399***	-0.413***	-0.414***	-0.415***
	(0.0951)	(0.0958)	(0.0957)	(0.0955)
$lnAid_{cjt}$	0.00597***	-0.000104	0.00185	0.00230
	(0.00139)	(0.00158)	(0.00181)	(0.00160)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
MR terms control	yes	yes	yes	yes
N	2460	2460	2460	2460
adj. R-sq	0.974	0.974	0.974	0.974

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at time t

The results show that the impact of different types of aid on aggregate export is small. Only the aid on infrastructure has a positive effect on export. The coefficient of the impact of infrastructure in the table means that one dollar spent on foreign assistance relative to infrastructure categories by Chinese government increases 0.117 dollars on China's exports.[18] Further analysis on the impact of aid (and specific types of aid) on different types of products and sectors is provided in next section.

5 Product level

In order to have an in-depth study on the impact of foreign aid on trade, we also analyze the effect at product level by using a Country-Product-Year fixed-effect methodology.[19] In this section, the bilateral export value will be decomposed at HS6 product level firstly and linked to overall unconditional aid, in general. Then a second analysis will be performed to analyze the impact of different types of aid on different types of goods (capital goods, intermediate goods, consumer goods and materials) exports.

[18]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.00597 * \frac{1.32e+13}{6.71e+11} = 0.117$.

[19]Data at HS6 product level is from BACI, provided by CEPII. Harmonized System (HS) for classifying goods is a six-digit code system.

5.1 HS6 product exports level

At HS6 product level, the impact of foreign aid on exports becomes smaller. Country-Year-HS6 fixed effect results are presented in table 5 and table 6. In order to have more detail, the sample is also split into different types of goods. The references to decompose the different types of goods are the database of HS Standard Product Groups, which are drawn from WITS.[20] According to this reference, products can be classified into capital goods, intermediate goods, consumer goods and materials. For example, capital goods including tools, machinery and equipment;[21] intermediate goods including producer goods or semi-finished.[22]

Table 5: Standard gravity estimation at HS6 products level

	(1) All	(2) Capital	(3) Intermediate	(4) Consumer	(5) Materials
lnY_{jt}	0.798***	0.746***	0.539***	0.829***	0.355***
	(0.00600)	(0.0143)	(0.0111)	(0.00873)	(0.0361)
$lnPop_{jt}$	0.534***	0.357***	0.170***	0.657***	0.235***
	(0.0121)	(0.0304)	(0.0240)	(0.0169)	(0.0664)
$lnER_{cjt}$	-0.125***	-0.0801***	-0.0398**	-0.0649***	0.0356
	(0.00993)	(0.0233)	(0.0176)	(0.0147)	(0.0618)
$lnAid_{cjt}$	0.00376***	0.00365***	0.00337***	0.00304***	0.00177*
	(0.000150)	(0.000371)	(0.000273)	(0.000220)	(0.000930)
Country FE	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes	yes
MR terms control	no	no	no	no	no
N	4672839	1083397	1462241	1900051	177142
adj. R-sq	0.532	0.328	0.438	0.62	0.415

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively
(c) Dependent variable : China's bilateral exports at product level at time t

In table 5, the first column translates the overall estimation: one dollar spent on foreign aid by Chinese government increases by 0.00004 dollars on average the value of product level export.[23] Among the further results in column (2), (3), (4) and (5), China's foreign aid increases the exports of capital, intermediate, consumer goods and materials but this effect on materials is smaller regarding to the coefficients of other goods.

When controlling for the MR term in table 6, the obtained coefficients are getting slightly smaller. Column (1) shows that every supplementary dollar spent on aid rises by 0.00004 dollar the export value at product level on average.[24] Similarly, the Chinese foreign assistance triggers, at product level, more exports on capital, intermediate consumer goods and materials, as showed in column (2), (3) and (4).

[20] https://wits.worldbank.org/referencedata.html

[21] e.g. Buckets, shovels, grabs and grips of excavating(HS6: 843141), Refrigerators(HS6: 841810, 841821, 841822, 841829) and Railway or tramway sleepers(HS6: 440610)

[22] e.g. Meat of bovine animals, salted... or smoked(HS6: 021012)

[23] The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.00376 * \frac{1.913e+13}{1.62e+15} = 0.000044368$.

[24] The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.00341 * \frac{1.913e+13}{1.62e+15} = 0.000040238$.

Table 6: Estimation at HS6 products level with MR terms

	(1) All	(2) Capital	(3) Intermediate	(4) Consumer	(5) Materials
lnY_{jt}	0.768***	0.672***	0.534***	0.798***	0.345***
	(0.00626)	(0.0148)	(0.0117)	(0.00904)	(0.0382)
$lnPop_{jt}$	0.594***	0.435***	0.264***	0.697***	0.281***
	(0.0122)	(0.0307)	(0.0243)	(0.0171)	(0.0672)
$lnER_{cjt}$	-0.166***	-0.151***	-0.0588***	-0.114***	0.0243
	(0.0100)	(0.0234)	(0.0178)	(0.0148)	(0.0630)
$lnAid_{cjt}$	0.00341***	0.00305***	0.00312***	0.00270***	0.00158*
	(0.000150)	(0.000371)	(0.000273)	(0.000220)	(0.000931)
Country FE	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes	yes
MR terms control	no	no	no	no	no
N	4672839	1083397	1462241	1900051	177142
adj. R-sq	0.528	0.327	0.434	0.615	0.412

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at HS6 level at time t

5.2 Aid heterogeneity at HS6 products level

In last sub-section, we investigate the overall influence of different aid categories at product level. We now turn to examine deeply this impact on different types of good by splitting the aiding categories.

The results of the impact of aid relative to infrastructure on exports of different kinds of goods are showed in Tables 11 and Table 12 (in the appendix). All in all, the foreign aid provided by China on infrastructure could enhance capital, intermediate and consumer goods trade. However it does not help China to export more materials. Tables 13- 14 (in the appendix) report the results of the impact of aid relative to productive capacity on export of different kind of goods. The coefficients of aid are positive but not statistically significant except for the case of intermediate goods. It shows that the aid provided by China relative to productive capacity could promote the trade in intermediate goods. Table 15- 16 (in the appendix) report the results of the impact of aid related to public welfare on export of different kinds of goods. The coefficient of aid is not statistically significant except for the case of consumer goods and materials. This means that if Chinese government provides aid related to public welfare, this reduces slightly the export of consumer goods and materials. Finally, table 17- 18 report the results of the effect of other aid category on export of different goods. The coefficients of aid are negative and not statistically significant for all goods categories except capital goods.

6 Trade margin

This section aims at investigating the link between China's foreign aid and export by decomposing trade margins. Along with Hummels et al. (2005), we compute product level and geographic level to measure trade margin.

First, the measurement of the trade extensive margins and intensive margins at prod-

uct level are as follows:

$$IM_{cw} = \frac{\sum_{i \in I_{cw}} p_{cwi} x_{cwi}}{\sum_{i \in I_{cw}} p_{kwi} x_{kwi}}$$

Where, IM_{cw} denotes the intensive margin; p is dollar value of a specific product i for an units, x is the number of units, c denotes China, w denotes the world, k denotes the countries/regions that excluded China. Thus, $p_{cwi}x_{cwi}$ is the dollar value of China's exports of product i to the world; $p_{kwi}x_{kwi}$ is the dollar value of world export of product i. Here the result of intensive margin means that for a given good, how many market share of China export to the world;

$$EM_{cw} = \frac{\sum_{i \in I_{cw}} p_{kmi} x_{kmi}}{\sum_{i \in I} p_{kmi} x_{kmi}}$$

Where, EM_{cw} represents the extensive margin; $p_{kmi}x_{kmi}$ is the overall traded goods in the world. In other words, the extensive margin measure the market share of the product that belongs to China's portfolio in world market.

Table 7: Country-HS6-Year fixed effect estimation on trade margin

	(1) EM	(2) EM	(3) IM	(4) IM
lnY_{jt}	0.132***	0.134***	0.0712***	0.0725***
	(0.000254)	(0.00027)	(0.000347)	(0.000376)
$lnPop_{jt}$	0.151***	0.145***	0.0505***	0.0532***
	(0.000573)	(0.000577)	(0.000405)	(0.000411)
$lnER_{cjt}$	-0.0729***	-0.0762***	-0.0399***	-0.0333***
	(0.000434)	(0.000442)	(0.000512)	(0.000517)
$lnAid_{cjt}$	0.00106***	0.00108***	0.000264***	0.000279***
	(7.14E-06)	(7.05E-06)	(7.13E-06)	(7.13E-06)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes
MR terms control	no	yes	no	yes
N	4652617	4652617	4652617	4652617
adj. R-sq	0.815	0.816	0.768	0.769

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively
(c) Dependent variable : China's trade margin at time t

(d) EM is the product extensive margin; IM is the product intensive margin.

Table 7 shows the impact of Chinese foreign aid on trade margins. The first and the second columns show the effect on extensive margin with and without MR variables control. The coefficients of aid variables are positive and statistically significant when applying Country-HS6-Year fixed effect. This shows that China's foreign aid could have a positive impact on increasing the market share with the existing trading partner. The results on intensive margin are presented in column (3) and (4). They underline that aid variables are both positive and statistically significant with and without controlling the MR factors. We could conclude that Chinese foreign aid can promote the trade of the already existing goods with the trading partners. In other words, it helps the country export more of the Chinese goods that are already exported at international level.

Moreover, the geographical trade margins are also computed by adapting the method of Hummels et al. (2005)by:

$$GIM_{cw} = \frac{\sum_{i \in D_{cw}} x_{cwi} n_{cwi}}{\sum_{i \in D_{cw}} x_{kwi} n_{kwi}}$$

Where, GIM_{cw} is the geographical intensive margin; $i \in D_{cw}$ is the set of destinations where China exports to; x is the export dollar value to every country on average; n is the number of destinations. Hence $p_{cwi}n_{cwi}$ is the dollar value of China's total exports to destination d; $p_{kwi}n_{kwi}$ is the dollar value exported to the same destination d by other countries. Hence, geographical intensive margin measures China's market share in the exporting destinations.

$$GEM_{cw} = \frac{\sum_{i \in D_{cw}} x_{kwi} n_{kwi}}{\sum_{i \in D_{w}} x_{kwi} n_{kwi}}$$

Where, GEM_{cw} is geographical extensive margin; $i \in D_w$ is the all the possible destinations in the world. Obviously geographical extensive margin is a measurement to understand the share of China's export destinations in the world market.

Table 8: Country fixed effect estimation on geographical trade margins

	(1) GEM	(2) GEM	(3) GIM	(4) GIM
lnY_{jt}	-0.0269***	-0.00999***	0.0465***	0.0171***
	(0.000562)	(0.000564)	(0.000923)	(0.000772)
$lnPop_{jt}$	-0.0351***	-0.0139***	0.0605***	0.0239***
	(0.00273)	(0.00199)	(0.00452)	(0.00264)
$lnER_{cjt}$	0.0255***	-0.000776	-0.0460***	-0.00104
	(0.00155)	(0.00136)	(0.00269)	(0.00186)
$lnAid_{cjt}$	-0.0000701***	-0.0000714***	0.0000941**	0.0000937***
	(0.0000258)	(0.0000203)	(0.0000387)	(0.0000273)
Country FE	yes	yes	yes	yes
Year FE	no	no	no	no
MR terms control	no	yes	no	yes
N	2400	2400	2400	2400
adj. R-sq	0.796	0.881	0.834	0.924

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively
(c) Dependent variable : China's trade margin at time t
(d) GEM is the geographic extensive margin; GIM is the geographical intensive margin.

The estimation of country fixed effect on geographical trade margins is reported in table 8.[25] The first column and the second column report how Chinese foreign aid impact geographical extensive margin under the control of MR terms or not. The negative significant sign of aid variable shows that foreign assistance could not help China expand to new markets by creating the trading relations with new partner. Concerning the geographical

[25]Geographical trade margins for a single country only vary from the year to year, but not change among different countries. Hence the results could only be caught by the country fixed effect.

intensive margin, the results with and without MR factors control are presented in column (3) and (4). The positive sign of aid variable underlines the fact that foreign aid could help getting more market shares in existing markets.

7 Robustness

In this section, we provide a battery of robustness checks to reinforce our results. We do this along three lines: adding more control, splitting the sample into different sub-sample and employing a different methodology.

In our first robustness check, we introduce more controls into the model: two additional variables are added to the already existent ones. As Liu et al. (2017) use trade freedom and FDI flow in their gravity model to investigate the link between China's foreign aid and trade, we follow this logic and include these two variables into our model. If we introduce, in turn, FDI inflows in China and Chinese FDI outflows, both of them have a negative sign in the our regression, therefore only the coefficients of FDI outflow is significant. Concerning the estimation with trade freedom and China's FDI in (table 19 in appendix), first and second column report the FDI outflow effects. The aid coefficients show that every dollar spent on foreign aid by Chinese government increase export value by 0.185-0.189.[26] The results obtained with trade freedom and China's FDI inflows are in column (3) and (4) (Table 19 in appendix), the aid variable could be documented that the return on export value is 0.182-0.186 if China provide foreign aid of one dollar.[27] Compared with the results of Liu et al. (2017) on the effect of China's foreign aid on export towards Africa, the trade elasticity that we obtain is smaller.

As a second robustness check, we split the panel across countries and across time. Hence, different groups of countries depending on their development level are considered. Moreover, we also take into account different time spans, in order to check the robustness of our results. In other words, we split the sample (i) into different sub-groups of countries, taking account of their income level, and (ii) into different sub-periods. Thus, the shocks and the heterogeneity of countries could be detected.

Thus, on the one hand, countries are separated into four income levels groups : low wage, low-middle wage, upper-middle wage and high wage countries. [28] Results are presented in Table 20 (in Appendix). China's foreign aid has a positive and significant impact on the exports to low and low-middle income countries. In the case of upper-middle income and high income countries, foreign aid is not significant in explaining bilateral trade between these countries and China.[29]

On the other hand, the time span has been divided into 3 sub-periods: 2000-2004, 2005-2009, 2010-2014. The impact of foreign aid on trade is not statistically significant when split the 5 years time spans (Table 21 in appendix). Moreover, to check the shock

[26]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.00578 * \frac{1.913e+13}{5.950e+11} = 0.1858; moreover, 0.00588 * \frac{1.913e+13}{5.950e+11} = 0.189.$

[27]The static terms is calculated as followed: $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.00567 * \frac{1.913e+13}{5.950e+11} = 0.182; moreover, 0.00577 * \frac{1.913e+13}{5.950e+11} = 0.185.$

[28]Data source on GNI per capita and classification of income level: World Bank.

[29]Dataset shows some flows of aid oriented towards high income countries, such as technical assistance, grants, loans and scholarships.

of financial crisis after 2008, we also add a dummy of crisis.[30] From the Column (4) in table 21, we find that the global financial crisis in 2008 has a negative impact on China's trade. However, the results indicate that one dollar spent on foreign aid leads to a 0.29 dollar rising of exports during the crisis.[31]

Our third robustness check supposes the use of a different methodology that can allow to deal with heteroskedasticity and potential zero trade problem. Hence, we use PPML (Poisson Pseudo Maximum Likelihood) setting, as Silva et al. (2006). The signs of variables hold, but the elasticity of variables is smaller than in the case of fixed effect and OLS methodology. The results (Table 22 in appendix) indicate that when China provides foreign aid of one dollar, this raises by 0.008-0.01 dollars the export value.[32]

8 Conclusion

Our results show that China's foreign aid has a positive impact on trade, result that has been confirmed only in the case of advanced countries acting as donors (Wagner, 2003; Martinez-Zarzoso et al. 2009 etc). On static terms, the return of every dollar spent on foreign aid shifts from 0.19$ to 0.41$ at aggregate level, while this amount is 0.00004$ at HS6 product level, on average. Moreover, we show that every dollar used on international aid in t-1 leads to an increase of 0.09-0.41 dollar of exports in t. With regard to the different types of aid, only aid on productive capacity has a positive impact on exports. In the meantime, Chinese government provide one dollar on the aids that is related to infrastructure, could increase 0.117 dollar on its exports; more specifically, the aid relative to infrastructure could enhance the exports of capital, intermediate, consumer goods expect materials; the aid relative to productive capacity promotes only the exports of intermediate goods while the aid relative to public welfare and other categories, do not seem to trigger more exports in any types of goods.

When we compute the trade margins we find that both extensive and intensive margins are significant at product level. Hence, foreign aid can promote the trade of new varieties of products to existing trading partners and help China export more of the already exchanged goods with trading partner. When considering the geographical trade margins, foreign aid could trigger larger market shares in existing markets but this could not initiate trade relations with new partners. When we take into account the trading partners' heterogeneity, we document that the "return" effect in low and low-middle income countries is stronger. Hence, the Chinese foreign aid has a positive impact on the South-South trade and cooperation. This "return" for the "good will" action, could motivate emerging countries to continue their aid. Nevertheless, crisis shocks limit the positive influence of Chinese foreign aid on exports. All in all, this study shows that Chinese foreign aid might potentially have a geo-cooperation and commercial development role. Furthermore, with regart to the emerging donor, they could also benefit from the foreign assistance.

Several policy implications can be derived. Foreign assistance seems to enhance

[30] Since the financial crisis started in 2008 and then spread at the global level, crisis dummy equals 1 from year 2009, otherwise 0.

[31] $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.00913 * \frac{1.913e+13}{5.950e+11} = 0.293$

[32] $\beta_{Aid} = \frac{\partial X}{\partial Aid_{cjt}} * \frac{Aid_{cjt}}{X}, thus, \frac{\partial X}{\partial Aid_{cjt}} = \beta_{Aid} * \frac{X}{Aid_{cjt}} = 0.000410 * \frac{1.913e+13}{5.950e+11} = 0.013; 0.000401 * \frac{1.913e+13}{5.950e+11} = 0.0129; 0.000299 * \frac{1.913e+13}{5.950e+11} = 0.0096; 0.0003 * \frac{1.913e+13}{5.950e+11} = 0.0096$

China's exports and furthermore to deepen the international integration. Hence, foreign aid could benefit the donor. If this result is linked to the context of China's project of "Belt and Road Initiative", it can be advanced that foreign aid can also be used as a complementary policy tool leading to benefits for both donor and recipients. From the perspective of self-interest, more "return" could be received when providing the aid on infrastructure and productive-capacity. Last but not least, foreign aid that is provided by emerging donor can also strengthen the "South-South" relationships, and induce mutual economic development.

Further research will be undertaken in order (1) to employ alternative methodologies (e.g. DOLS); (2) to study the impact of China's foreign aid on import; (3) study the aid-trade nexus by using more emerging countries as donors.

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Appendix A

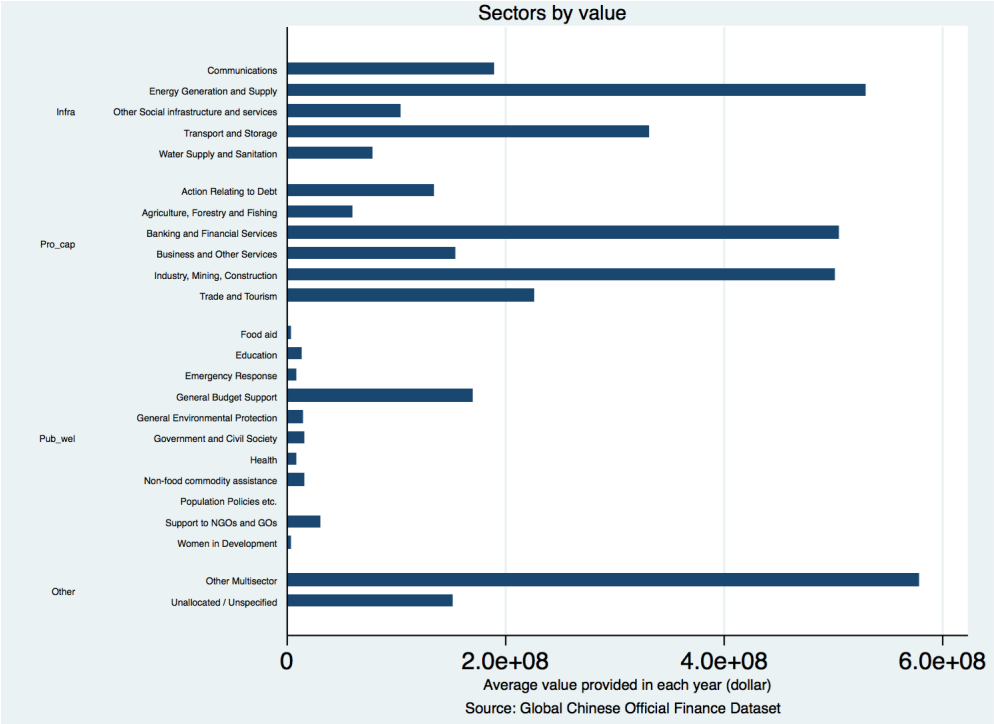

Figure 1: Aiding sectors splitted into categories by value

Appendix B

Table 9: Country list

Albania	Algeria	Angola	Antigua and Barbuda
Argentina	Armenia	Australia	Austria
Azerbaijan	Bahamas, The	Bahrain	Bangladesh
Barbados	Belarus	Belgium	Belize
Benin	Bhutan	Bolivia	Bosnia and Herzegovina
Botswana	Brazil	Brunei	Bulgaria
Burkina Faso	Burundi	Cambodia	Cameroon
Canada	Cape Verde	Central African Republic	Chad
Chile	Colombia	Comoros	Congo, Rep.
Costa Rica	Croatia	Cyprus	Czech Republic
Cote d'Ivoire	Denmark	Djibouti	Dominica
Dominican Republic	Ecuador	Egypt	El Salvador
Equatorial Guinea	Estonia	Ethiopia	Fiji
Finland	France	Gabon	Gambia
Georgia	Germany	Ghana	Greece
Greenland	Grenada	Guatemala	Guinea
Guinea-Bissau	Guyana	Haiti	Honduras
Hong Kong, China	Hungary	Iceland	India
Indonesia	Iran, Islamic Rep.	Ireland	Israel
Italy	Jamaica	Japan	Jordan
Kazakhstan	Kenya	Kiribati	Korea, Rep.
Kuwait	Kyrgyz Republic	Lao PDR	Latvia
Lebanon	Lesotho	Liberia	Lithuania
Luxembourg	Macau, China	Macedonia, FYR	Madagascar
Malawi	Malaysia	Maldives	Mali
Malta	Marshall Is	Mauritania	Mauritius
Mexico	Micronesia	Moldova	Mongolia
Morocco	Mozambique	Myanmar	Namibia
Nepal	Netherlands	New Zealand	Nicaragua
Niger	Nigeria	Norway	Oman
Pakistan	Palau	Panama	Papua New Guinea
Paraguay	Peru	Philippines	Poland
Portugal	Qatar	Russian Federation	Rwanda
Samoa	Sao Tome Prn	Saudi Arabia	Senegal
Seychelles	Sierra Leone	Singapore	Slovak Republic
Slovenia	Solomon Islands	South Africa	Spain
Sri Lanka	St. Kitts and Nevis	St. Lucia	Vincent and the Grenadines
Suriname	Swaziland	Sweden	Switzerland
Tajikistan	Tanzania	Thailand	Togo
Tonga	Trinidad Tobago	Tunisia	Turkey
Turkmenistan	Uganda	Ukraine	United Arab Emirates
United Kingdom	United States	Uruguay	Uzbekistan
Vanuatu	Vietnam	Yemen	Zambia
Zimbabwe			

Table 10: Correlation

	lnX	$ln(Y_{ct})$	$ln(Y_{jt})$	$ln(Pop_{jt})$	$ln(DIS_j)$	CON	$ln(ER_{cjt})$	$ln(Aid_{cjt})$
lnX	1							
$ln(Y_{ct})$	0.3894	1						
$ln(Y_{jt})$	0.4709	0.2215	1					
$ln(Pop_{jt})$	0.6558	0.0356	-0.144	1				
$ln(DIS_j)$	-0.3294	0	-0.0712	-0.2444	1			
CON	0.1259	0	-0.1706	0.1599	-0.5309	1		
$ln(ER_{jt})$	-0.0267	-0.182	0.061	0.0014	0.0142	0.0684	1	
$ln(Aid_{jt})$	-0.0179	0.135	-0.46	0.2052	-0.0629	0.186	-0.0301	1
RTA	0.3679	0	0.1282	0.3101	-0.4571	0.3583	-0.0298	0.0503

Table 11: The impact of aid related to infrastructure on different types of goods (standard gravity model)

	(1) Capital	(2) Intermediate	(3) Consumer	(4) Materials
lnY_jt	0.864***	0.502***	0.602***	0.369***
	(0.0215)	(0.0192)	(0.0143)	(0.0583)
$lnPop\_jt$	0.479***	-0.0799**	0.697***	-0.0566
	(0.0336)	(0.0338)	(0.0225)	(0.0849)
$lnER\_cjt$	-0.0402	-0.0131	0.226***	-0.0975
	(0.0377)	(0.0331)	(0.0247)	(0.0948)
$lnAid\_cjt$	0.00520***	0.00506***	0.00361***	-0.00305
	(0.00105)	(0.000914)	(0.000774)	(0.0032)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes
MR terms control	no	no	no	no
N	545877	778279	974217	111124
adj. R-sq	0.618	0.458	0.672	0.443

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at HS6 product level.

Table 12: The impact of aid related to infrastructure on different types of goods (with MR terms)

	(1) Capital	(2) Intermediate	(3) Consumer	(4) Materials
lnY_{jt}	0.890***	0.629***	0.639***	0.419***
	(0.0223)	(0.02)	(0.0148)	(0.0608)
$lnPop_{jt}$	0.553***	0.0415	0.767***	-0.0128
	(0.0339)	(0.0342)	(0.0228)	(0.0855)
$lnER_{cjt}$	-0.0214	0.0801**	0.198***	-0.103
	(0.0385)	(0.0341)	(0.0252)	(0.0986)
$lnAid_{cjt}$	0.00501***	0.00571***	0.00365***	-0.00287
	(0.00105)	(0.000917)	(0.000775)	(0.00321)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes
MR terms control	yes	yes	yes	yes
N	545877	778279	974217	111124
adj. R-sq	0.618	0.459	0.672	0.443

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at HS6 product level.

Table 13: The impact of aid relative to productive capacity on different types of goods (standard gravity model)

	(1) Capital	(2) Intermediate	(3) Consumer	(4) Materials
lnY_jt	0.915***	0.436***	0.704***	0.270***
	(0.0218)	(0.0193)	(0.0153)	(0.0584)
$lnPop_{jt}$	0.357***	-0.170***	0.570***	-0.0755
	(0.0335)	(0.0336)	(0.0224)	(0.0843)
$lnER\_cjt$	-0.118***	-0.00413	0.00349	0.0132
	(0.0341)	(0.0285)	(0.0246)	(0.0882)
$lnAid_{cjt}$	0.000783	0.00454***	0.000823	0.00352
	(0.00144)	(0.00127)	(0.00106)	(0.00444)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes
MR terms control	no	no	no	no
N	522540	748743	939035	108046
adj. R-sq	0.622	0.46	0.679	0.446

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at HS6 product level.

Table 14: The impact of aid relative to productive capacity on different types of goods (with MR terms)

	(1) Capital	(2) Intermediate	(3) Consumer	(4) Materials
lnY_{jt}	0.956***	0.569***	0.739***	0.315***
	(0.0227)	(0.0204)	(0.0157)	(0.0609)
$lnPop_{jt}$	0.431***	-0.0305	0.641***	-0.026
	(0.0339)	(0.0341)	(0.0227)	(0.085)
$lnER_{cjt}$	-0.124***	0.0205	-0.0408	-0.0104
	(0.0346)	(0.029)	(0.025)	(0.091)
$lnAid_{cjt}$	0.000235	0.00380***	0.000487	0.00293
	(0.00144)	(0.00127)	(0.00106)	(0.00444)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes
MR terms control	yes	yes	yes	yes
N	522540	748743	939035	108046
adj. R-sq	0.622	0.46	0.68	0.446

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at HS6 product level.

Table 15: The impact of aid relative to public welfare on different types of goods (standard gravity model)

	(1) Capital	(2) Intermediate	(3) Consumer	(4) Materials
lnY_{jt}	0.934***	0.468***	0.685***	0.366***
	(0.0205)	(0.0191)	(0.0142)	(0.0584)
$lnPop_{jt}$	0.444***	-0.107***	0.633***	-0.0245
	(0.0323)	(0.0328)	(0.0217)	(0.0831)
$lnER_{cjt}$	-0.275***	-0.0448	0.00481	-0.134
	(0.0351)	(0.0316)	(0.0238)	(0.0927)
$lnAid_{cjt}$	-0.000959	-0.000139	-0.00150***	-0.00528**
	(0.000771)	(0.000728)	(0.000544)	(0.0026)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes
MR terms control	no	no	no	no
N	589240	817573	1054586	112603
adj. R-sq	0.609	0.452	0.667	0.446

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively
(c) Dependent variable : China's bilateral exports at HS6 product level.

Table 16: The impact of aid relative to public welfare on different types of goods (with MR terms)

	(1) Capital	(2) Intermediate	(3) Consumer	(4) Materials
lnY_{jt}	0.982***	0.593***	0.726***	0.419***
	(0.0211)	(0.0197)	(0.0145)	(0.0603)
$lnPop_{jt}$	0.509***	0.024	0.695***	0.0194
	(0.0326)	(0.0331)	(0.0219)	(0.0837)
$lnER_{cjt}$	-0.296***	-0.0151	-0.0526*	-0.157
	(0.0357)	(0.0324)	(0.0242)	(0.0964)
$lnAid_{cjt}$	-0.00125	-0.000532	-0.00184***	-0.00549**
	(0.000771)	(0.000729)	(0.000544)	(0.0026)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes
MR terms control	yes	yes	yes	yes
N	589240	817573	1054586	112603
adj. R-sq	0.609	0.453	0.667	0.446

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively
(c) Dependent variable : China's bilateral exports at HS6 product level.

Table 17: The impact of aid relative to other categories on different types of goods (standard gravity model)

	(1) Capital	(2) Intermediate	(3) Consumer	(4) Materials
lnY_jt	0.942***	0.343***	0.597***	0.316***
	(0.0234)	(0.0214)	(0.0156)	(0.0619)
$lnPop_{jt}$	0.374***	-0.135***	0.575***	-0.0861
	(0.0337)	(0.0339)	(0.0226)	(0.0845)
$lnER_{cjt}$	-0.166***	0.114***	0.201***	-0.0735
	(0.0398)	(0.0356)	(0.026)	(0.098)
$lnAid_{cjt}$	-0.00415**	-0.00296	-0.00236*	0.0063
	(0.00204)	(0.00184)	(0.00138)	(0.00738)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes
MR terms control	no	no	no	no
N	495308	702216	900723	103135
adj. R-sq	0.626	0.463	0.685	0.454

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at HS6 product level.

Table 18: The impact of aid relative to other categories on different types of goods (with MR terms)

	(1) Capital	(2) Intermediate	(3) Consumer	(4) Materials
lnY_{jt}	0.987***	0.474***	0.648***	0.359***
	(0.0241)	(0.0221)	(0.016)	(0.064)
$lnPop_{jt}$	0.446***	0.0066	0.647***	-0.04
	(0.034)	(0.0343)	(0.0228)	(0.0851)
$lnER_{cjt}$	-0.163***	0.166***	0.147***	-0.101
	(0.0406)	(0.0366)	(0.0266)	(0.102)
$lnAid_{cjt}$	-0.00422**	-0.00255	-0.00193	0.00629
	(0.00204)	(0.00184)	(0.00138)	(0.00739)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
HS6 FE	yes	yes	yes	yes
MR terms control	yes	yes	yes	yes
N	495308	702216	900723	103135
adj. R-sq	0.626	0.463	0.685	0.454

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at HS6 product level.

Table 19: Robustness check with additional variables

	(1) FE	(2) FE	(3) FE	(4) FE
lnY_{jt}	1.142***	1.146***	1.136***	1.142***
	(0.0706)	(0.0739)	(0.0704)	(0.0739)
$lnPop_{jt}$	1.001***	0.983***	0.977***	0.961***
	(0.106)	(0.107)	(0.107)	(0.108)
$lnER_{cjt}$	-0.411***	-0.411***	-0.411***	-0.410***
	-0.0891	-0.0895	-0.0901	-0.0905
$lnAid_{cjt}$	0.00578***	0.00588***	0.00567***	0.00577***
	(0.00147)	(0.00147)	(0.00148)	(0.00147)
$Tradefreedom$	0.00300**	0.00289**	0.00299**	0.00287**
	(0.00132)	(0.00132)	(0.00132)	(0.00132)
$lnFDI_{outflow}$	-0.0251***	-0.0246***		
	(0.00763)	(0.00762)		
$lnFDI_{inflow}$			0.000827	0.000683
			(0.00198)	(0.00199)
Country FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes
MR terms control	no	yes	no	yes
N	2277	2277	2277	2277
adj. R-sq	0.977	0.977	0.977	0.977

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at time t.

Table 20: Robustness check with different income level countries

	(1) Low	(2) Low middle	(3) Upper middle	(4) High
lnY_{jt}	1.076***	0.816***	0.793***	0.629***
	(0.142)	(0.0829)	(0.136)	(0.0699)
$lnPop_{jt}$	0.907***	1.042***	1.017***	1.055***
	(0.0528)	(0.0218)	(0.0334)	(0.0287)
$lnER_{cjt}$	-0.538**	-0.182**	-0.105	-0.520**
	(0.216)	(0.0788)	(0.113)	(0.231)
$lnAid_{cjt}$	0.0238***	0.0253***	-0.00539	0.00909
	(0.00811)	(0.00422)	(0.00515)	(0.0139)
Country FE	no	no	no	no
Year FE	yes	yes	yes	yes
MR terms control	yes	yes	yes	yes
N	569	646	551	710
adj. R-sq	0.633	0.87	0.849	0.871

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively

(c) Dependent variable : China's bilateral exports at time t.

Table 21: Robustness check: crisis

	(1) 2000-2004	(2) 2005-2009	(3) 2010-2014	(4) Crisis
lnY_{jt}	1.555***	1.601***	1.056***	1.659***
	(0.155)	(0.119)	(0.175)	(0.0638)
$lnPop_{jt}$	2.018***	2.542***	1.640***	1.813***
	(0.745)	(0.366)	(0.368)	(0.145)
$lnER_{cjt}$	-0.606***	-0.984***	-0.525**	-0.510***
	(0.170)	(0.230)	(0.239)	(0.107)
$lnAid_{cjt}$	0.00535*	0.00158	0.00401**	0.00913***
	(0.00282)	(0.00215)	(0.00204)	(0.00182)
Crise				-0.132***
				(0.0403)
Country FE	yes	yes	yes	yes
Year FE	no	no	no	no
MR terms control	yes	yes	yes	yes
N	825	825	825	2475
adj. R-sq	0.978	0.986	0.987	0.968

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively
(c) Dependent variable : China's bilateral exports at time t.

Table 22: PPML fixed effect estimation

	(1) Country FE	(2) Country FE	(3) Year FE	(4) Year FE
lnY_{jt}	0.0975***	0.0869***	0.0615***	0.0612***
	(0.00489)	(0.00703)	(0.00828)	(0.00869)
$lnPop_{jt}$	0.106***	0.0949***	0.0670***	0.0652***
	(0.0236)	(0.0238)	(0.0203)	(0.0204)
$lnER_{cjt}$	-0.0369***	-0.0243**	-0.0177*	-0.0182*
	(0.00747)	(0.0102)	(0.01)	(0.0101)
$lnAid_{cjt}$	0.000410***	0.000401***	0.000299***	0.000300***
	(0.000105)	(0.000101)	(0.0000898)	(0.0000888)
Country FE	yes	yes	yes	yes
Year FE	no	no	yes	yes
MR terms	no	yes	no	yes
N	2339	2339	2339	2339
adj. R-sq	0.815	0.825	0.853	0.855

Notes:
(a) Robust standard errors in parentheses
(b) ***, **, and * denote significance at 1, 5 and 10% level, respectively
(c) Dependent variable : China's bilateral exports

Appendix C

We follow the method of Baier and Bergstrand (2009), to explain how we construct the multilateral resistance terms.

$$X_{cjt} = \frac{Y_{ct}Y_{jt}}{Y_{wt}} * (\frac{t_{cjt}}{P_{ct}P_{jt}})^{1-\sigma} \tag{1}$$

Where:

$$P_{ct} = [\sum_{j=1}^{N}(\frac{\theta_{jt}}{t^{\sigma-1}})P_j^{\sigma-1}]^{\frac{1}{1-\sigma}} \tag{2}$$

$$P_{jt} = [\sum(\frac{\theta_{ct}}{t^{\sigma-1}})P_c^{\sigma-1}]^{\frac{1}{1-\sigma}} \tag{3}$$

θ_{jt} and θ_{ct} denote $\frac{Y_{ct}}{Y_{wt}}$ and $\frac{Y_{jt}}{Y_{wt}}$, respectively. These measures are considered as "economic density."
A first-order log-linear Taylor series expansion is employed for equation (2) and (3). We begin with equation (2) by dividing a constant $t^{\frac{1}{2}}$:

$$P_{ct}/t^{\frac{1}{2}} = [\sum_{j=1}^{N}\theta_{jt}\frac{(\frac{t_{cj}}{t^{\frac{1}{2}}})^{1-\sigma}}{P_j^{\sigma-1}}]^{\frac{1}{1-\sigma}} \tag{4}$$

$$P_{ct}/t^{\frac{1}{2}} = [\sum_{j=1}^{N}\theta_{jt}(\frac{t_{cj}/t}{P_j/t^{\frac{1}{2}}})^{1-\sigma}]^{\frac{1}{1-\sigma}}$$

Define $\tilde{P_c}=\frac{P_c}{t^{\frac{1}{2}}}$, $\tilde{P_j}=\frac{P_j}{t^{\frac{1}{2}}}$ and $\tilde{t_{cj}}=\frac{t_{cj}}{t}$, the equation (4) could be written as:

$$\tilde{P_c} = [\sum_{j=1}^{N}\theta_{jt}(\tilde{t_{cj}}/\tilde{P_j})^{1-\sigma}]^{\frac{1}{1-\sigma}} \tag{5}$$

And

$$e^{(1-\theta)ln\tilde{P_c}} = \sum_{j=1}^{N} e^{ln(\theta_j)}e^{(\sigma-1)}e^{\tilde{P_j}}e^{\tilde{t_{cj}}} \tag{6}$$

Here, the e is the natural logarithm. Based on the model of Anderson et al. (2003), they assume that the trade costs are symmetric bilaterally, which means that t_{cj}=t_{jc}. Thus, t_{cj}=$t(t>0)$, implying $\tilde{t_{cj}} = 1$. We have:

$$\tilde{P_c}^{1-\sigma} = \sum_{j=1}^{N} \theta_j \tilde{P_j}^{\sigma-1} \tag{7}$$

We further multiply both sides by $\tilde{P_c}^{\sigma-1}$, as noted in Feenstra (2004)[33], the solution for latter multiplying is $\tilde{P_c} = \tilde{P_j} = \tilde{t_{cj}} = 1$. The first-order log-linear Taylor-series expansion of equation (6), centered at $\tilde{P_c} = \tilde{P_j} = \tilde{t_{cj}} = 1$, yields:

$$lnP_c = -\sum_{j=1}^{N} \theta_j lnP_j + \sum_{j=1}^{N} \theta_j t_{cj} \tag{8}$$

And

$$lnP_j = -\sum \theta_c lnP_c + \sum \theta_c t_{cj} \tag{9}$$

Under the assumption of the trade costs are symmetric bilaterally, the solution to equations (8) and (9) could be:

$$lnP_c = \sum_{j=1}^{N} \theta_j lnt_{cj} - \frac{1}{2} \sum_{k=1}^{N} \sum_{m=1}^{N} \theta_k \theta_m lnt_{km} \tag{10}$$

$$lnP_j = \sum \theta_c lnt_{cj} - \frac{1}{2} \sum_{k=1}^{N} \sum_{m=1}^{N} \theta_k \theta_m lnt_{km} \tag{11}$$

Furthermore, we include the time-varying effect by modifying the specification of Baier et al. (2009). For the case of $MRT_{cjt} = lnP_c t + lnP_j t$, we have:

$$MRT1_{cjt} = \sum \theta_{ct} lnt_{cjt} + \sum_{j=1}^{N} \theta_{jt} lnt_{cjt} - \sum_{k=1}^{N} \sum_{m=1}^{N} \theta_{kt} \theta_{mt} lnt_{kmt} \tag{12}$$

Finally we include the unobservable t_{ijt} into the multilateral resistance terms:

$$MRT_{cjt} = t_{ijt} - \sum \theta_{ct} lnt_{cjt} - \sum_{j=1}^{N} \theta_{jt} lnt_{cjt} + \sum_{k=1}^{N} \sum_{m=1}^{N} \theta_{kt} \theta_{mt} lnt_{kmt} \tag{13}$$

[33] p. 158, footnote 11