Trade effects of the euro:
A non-parametric assessment using value added data

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Abstract

This work aims to offer a twofold original contribution to the debate on the euro's trade effect. First, it innovates the previous literature that assessed the euro impact mainly through gravity analyses (see the surveys by Baldwin et al., 2008, Head and Mayer, 2014, and lastly Rose, 2016) by applying non-parametric matching techniques that control for nonlinearity-with-self selection. Second, it assesses the euro's effect on the value added components of gross exports and presents tentative interpretations of the divergences between results using value added rather than gross data. Specifically, following Baier and Bergstrand (2009), we employ the nearest three neighbours matching estimator developed by Abadie and Imbens (2006) as well as the DID approach to control for time effects. Value added components are computed over the period 1995-2011 using the World Input Output Database and the methodology proposed by Wang et al. (2013). The latter has the advantage to provide bilateral (as well as dyadic) components of value added trade among the 39 countries in the sample. Preliminary results show that, differently from many gravity assessments of the euro effects, our matching estimates show a positive effect of the euro on bilateral trade and this result extends also to the outcomes that takes into account the fragmentation of production in the Eurozone. However, if we look at changes in trade flows the hypothesis of a euro positive effect is less convincing. Whereas our aim is not to provide clear-cut conclusions on the old debate about the euro's impact on bilateral trade, we strongly believe that our results - and the provided set of robustness checks - surely contribute to enhance our understanding of the euro's impact and its policy implications.

Keywords: euro, production fragmentation, non-parametric estimates, trade in value added, EU

JEL codes: F10, F12, F15, F33

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1. Introduction

More than 15 years after its establishment, the assessment of the actual impacts of the euro is still controversial. Starting with Rose (2000), a large amount of works focused the attention specifically on the euro's impact on trade, providing a wide range of results (see the surveys by Baldwin et al., 2008, Head and Mayer, 2014, and lastly Rose, 2016). Most of these works have employed the gravity model as the workhorse method to detect the partial effect of a currency union on bilateral trade, taking advance of the theoretical advancement started with the work by Anderson and van Wincoop (2003). Nevertheless, some authors have suggested the adoption of alternative empirical strategies. In particular, Persson (2001) was among the first to highlight the risk of possible biases due to nonlinearity-with-self-selection problem by using the log-linear gravity equation. Thus, a recent strand of the literature is increasingly applying matching techniques for the analysis of free trade agreements (Baier and Bergstrand, 2009; Katayama and Melatos, 2011; Montalbano and Nenci, 2014; Magrini et al., 2017).

At the same time, a broad literature arose that aimed to study the impact of the international fragmentation of production on trade (see Grossman and Rossi-Hansberg, 2008; Baldwin, 2011, 2012, 2014; Antràs et al. 2012; Costinot et al., 2013; Baldwin and Venables, 2013; Baldwin and Lopez-Gonzalez, 2015), also measuring trade in value added terms (Koopman et al., 2014; Timmer et al., 2014; Stehrer, 2013; Grossman, 2011). A recent strand of this literature focuses on the Eurozone and argued that single currency and trade fragmentation effects are indeed interlinked (Rotili, 2014; Montalbano et al., 2016). Moreover, also this new literature emphasizes possible limitations of the gravity approach and calls for additional in-depth theoretical discussion (Baldwin and Taglioni, 2014; Noguera, 2012; Johnson and Noguera, 2016; Aichele and Heiland, 2016).

Starting from these findings, this work aims to offer a twofold original contribution to the debate on the euro's trade effect. First, it applies non-parametric matching techniques for the assessment of the euro effect that controls for nonlinearity-with-self selection. Specifically, we employ a Propensity Score Matching (PSM) and, following Baier and Bergstrand (2009), the Nearest-Neighbour Matching (NNM) estimators developed by Abadie and Imbens (2006) as well as a combined Nearest-Neighbour Matching (NNM)-Difference-in-Difference (DID) approach to take full advantage of the longitudinal dimension of the data. Second, it assesses the euro's effect on the value added components of gross exports which are computed using the World Input Output Database (WIOD)[3] and the methodology proposed by Wang et al. (2013). The latter has the advantage to provide bilateral (as well as dyadic) components of value added trade among the

[3] WIOD combines international trade statistics, input-output tables and national accounts in order to disentangle gross exports in final and intermediate goods. For details see Section 6.

countries in the sample. To the best of our knowledge, this work is the first to assess the euro's effect on trade using both value added trade data and non-parametric techniques.

Preliminary results show that, consistently with the most recent gravity assessments of the euro effects, our matching estimates do not show a positive effect of the euro on bilateral trade and this result extends also to the outcomes that takes into account the fragmentation of production in the Eurozone. Further insights are provided looking at the value added components as shares of total export flows. In this latter case, whereas the matching exercise seems to support the hypothesis of the presence of a process of fragmentation of production within the Eurozone members after the adoption of the euro, when we move to the NNM-DID exercise, the trade in value added component that actually increased in changes after the euro adoption for the Eurozone members is exclusively the domestic value added destined to direct importing partners or third countries (DVA). Whereas our aim is not to provide clear-cut conclusions on the old debate about the euro's impact on bilateral trade, we strongly believe that our results - and the provided set of robustness checks - surely contribute to enhance our understanding of the euro's impact and its policy implications.

The structure of the paper is as follows. Section 2 presents a survey of the most relevant studies investigating the impact of euro on trade. Section 3 addresses the estimation methodologies. Section 4 contains a description of variables and a presentation of the data source. Section 5 shows the empirical outcomes. Section 6 provides a set of robustness checks. Section 7 concludes.

2. The euro effect on trade: a review of the literature

In his theory of optimal currency area, Mundell (1961) argues that an increase in trade volume would be the main benefit when nations join a currency union. Important contributions have followed[4], suggesting several theoretical arguments in favour of the positive impact of the common currency adoption on bilateral trade. First, the common currency can have a trade-promoting effect thanks to its contribution to a reduction in transaction, administration and information costs as well as the removal of uncertainty on exchange rate volatility between member countries (Flam, 2008). Moreover, in a world with international fragmentation of production where intermediate goods cross borders multiple times before being assembled and sold as a final good, the direct impact of a small reduction in transaction costs could increase trade flows in a non-linear way (Sadeh, 2014). Second, the lower costs of exporting could stimulate exports of existing firms and foster previously non-exporting firms to start exporting within the common currency area, increasing the variety of exported products (Melitz, 2003; Baldwin et al. 2008; Helpman et al., 2008). Therefore, if these

[4] For an extensive discussion, see Broz (2005).

products were previously imported from other non-member countries, the increasing trade within the common currency area could result from the "diversion" of imports from non-member to member countries.

As data on the Eurozone countries progressively became available, scholars started to focus their attention on the euro's impact on trade. Micco et al. (2003) provided the first evaluation of the euro's trade effect followed by de Nardis and Vicarelli (2003), Flam and Nordstrom (2003, 2006, 2007), Bun and Klasssen (2007), Baldwin and Taglioni (2007), Berger and Nitsch (2008), de Nardis et al. (2007) and Gil-Pareja et al. (2008). These studies offered a wide range of (positive, negative or no impact) results, using different datasets in terms of years, country covered and types of currency unions, different specifications of the gravity equation and different econometric techniques. Most of this literature has been ably reviewed and synthesized by Baldwin (2006) and Baldwin et al. (2008), highlighting the common misspecifications and econometric errors that flaw a relevant number of the published estimates - starting from Baldwin's "medals" - but also the most interesting advances proposed by each works to enhance our understanding of the euro's trade effect. The latest work on the euro effect on boosting trade is provided by Glick and Rose (2016) who updated their seminal article (Glick and Rose, 2002) adopting newer and consensus estimation techniques. Using a dataset that covers more than 200 countries between 1948 and 2013 and a panel approach with both dyadic and time-varying exporter and importer fixed effects, Glick and Rose (2016) conclude that the euro has had a relevant positive effect on trade of about 50%. Moreover, they provide evidence that the Eurozone seems to have a different impact from other currency unions - confirming the previous result by Havranek (2010) - and that each currency union tends to have its own effect on trade. Therefore, focusing on the euro, Glick and Rose (2016) claim that "observations need to be modelled differently from other currency union observations". This outcome, which includes fifteen years of data for the Eurozone, is strong support for analysis that specifically focuses on the euro's effect on trade, like the one in this work.

Although the fragmented nature of the literature on the trade effects of common currency (in terms of datasets, specification of the model and econometric techniques) makes systematic comparison difficult, some scholars have proposed meta-analyses. The first are Rose and Stanley (2005) who present an early meta-analysis on this subject using a combined sample of 34 studies on both the Eurozone (7 papers) and other currency unions. Their analysis reports a general impact between 30 and 90%, embedding estimates from -0.378 (Pakko and Wall, 2001) to 1.38 (Melitz, 2002). Havranek (2010) updates this work with new studies, 21 of which focus on the euro, extending the sample to 61 papers up until 2006[5]. Separating the effects of the euro and other currency unions, this author shows that the differences are important and thus that it is more appropriate to assess these two strands of literature distinctly. Head and Mayer (2014) have performed a well-known meta-analysis on a large set of variables used in the gravity framework to model international trade. For the “common currency” variable, they report a mean effect of 0.79 over 104 estimates, corresponding to a doubling of trade, but they warn the reader that this result should not be interpreted as a preferred estimate of the causal effects of the policy variable because, by and large, the 104 estimates fail to address the endogeneity issue[6]. More recently, Rose (2016) has quantitatively summarized the euro literature showing how much the estimates vary across the 45 papers circulating at that time (25 of which were published). Renewing the argument expressed by Frankel (2010), Rose’s explanation is that estimates of the euro’s trade effects vary because researchers use different samples of countries and years to estimate this impact. According to Rose (2016), excluding observations, especially by country, bias downward the estimates of the time-varying country fixed effects - which catch the Anderson and van Wincoop (2003)’s “multilateral resistance” terms - and thus leads to a downward bias in the euro’s effect on trade.

More recent papers on the euro’s trade effects point out some relevant issues driven by the need to assimilate not only the advances in the field of econometrics, but also the contributions of the literature to the international fragmentation of production. Indeed, this phenomenon has modified the nature of trade flows and the kind of traded goods and services. Appling a non-linear Poisson maximum-likelihood estimator to a sample of 22 OECD countries covering the years 1993-2007, Santos Silva and Tenreyro (2010) find that the euro has a negligible effect on trade. Other recent works propose different methodological approaches. De Camarero et al. (2014) apply panel cointegration techniques to a dataset with 26 OECD countries for the period 1967–2008 in order to consider the adoption of the euro as a progression of policy changes. They show that the euro's trade effect is small, but still positive. Figueiredo et al. (2016) apply quantile regressions for panel data. They use different dataset in terms of country coverage for the period 1993 - 2007. Their results show that even with this approach the euro’s effect on trade remains bleak.

The work by Baldwin and Taglioni (2014) was the first attempt to incorporate the issues of the international fragmentation of production in the gravity framework. In particular, they present

[5] It is interesting to note that Havranek (2010) detects a strange publication bias led by the authorship of the papers: those by Rose and co-authors tend to report higher (positive) euro trade effects whereas papers co-authored by Baldwin are more likely to find smaller results.

[6] Although the essence of meta-analysis is to use all available studies, including biased and misspecified results, some scholars - especially Baldwin (2006) - severely doubt the usefulness of summary statistic emerging from meta-analysis for policy purposes when these analysis include estimates that are entirely lacking credibility due to methodological mistakes.

empirical evidence that a gravity analysis based on gross exports alone may perform poorly in a world in which parts and components trade is relevant. When international trade in intermediate goods dominates, the authors suggest a better empirical specification of the gravity equation for the studies that proxy for the production and demand variables with GDP. Although at present the fixed effect approach has become the standard to control for mass variables correctly and thus newer researches are unaffected by their critique, Baldwin and Taglioni (2014) have received merit for reviving an original intuition by Flam and Nordstom (2006) that the formation of the Eurozone is encouraging the fragmentation of production among member countries. In the same vein, Rotili (2014) using the first release of the World Input Output Dataset (WIOD) finds that the euro has positively affected bilateral exports among Eurozone members, with a larger effect on intermediate flows relative to final exports, but only on a subset of the WIOD's countries including 19 advanced economies. Moreover, Kelejian et al. (2012) integrate the spatial analysis in the gravity framework to control for spatial correlation and account for third country effects in estimating the effects of the euro on trade. They find almost no significant effect of the euro on bilateral trade flows among Eurozone countries. Johnson and Noguera (2016) were the first to propose a multi-sector structural gravity model with input-output linkages to analyse the divergence between value added and gross trade over time. These authors argue that the standard gravity equation cannot fully explain the pattern of bilateral value added trade because bilateral value added flows do not depend only on bilateral trade costs but also on costs with third countries through which value added transits from source to destination. However, at present, the theoretical analysis of value added trade in gravity models is still in their infancy and the links between trade policy and value added trade is an appealing and largely unexplored territory (Kaplan et al., 2016, Baliè et al., 2017; Blanchard et al., 2017; Aichele and Heiland 2016).

3. Methodology

In this exercise we use non-parametric estimates based on matching econometrics to allow for non-linear effects of currency unions as well as for systematic selection among currency union members (Persson, 2001; Alesina et al., 2003; Nitsch, 2004; Baldwin, 2006; Katayama and Melatos, 2011; Saia, 2017). Non-parametric estimates are, by definition, not affected by the methodological constraints imposed by log-linear gravity equations. Matching estimators compare treated and untreated country pairs across a number of relevant observable characteristics. Therefore we disentangle our sample of countries into a treatment group, formed by the country pairs in which both countries adopt the euro, and a control group, where one or both countries in the pair do not adopt the euro. We can thus measure the average treatment effect (ATE) - that is the average of the euro's trade effect on both treated and untreated country pairs - as well as the average treatment effect on a pair of Eurozone countries, i.e. the treated (ATT).

In a first step, we estimate the euro's effect on bilateral trade (gross exports or value added components) by appling two alternative non-parametric techniques: the Propensity score matching (PSM) developed by Rosenbaum and Rubin (1983) and the Nearest-Neighbour Matching estimator (NNM) more recently proposed by Abadie and Imbens (2006, 2011). The traditional PSM approach performs the matching on only one characteristic that synthetizes all the information available: the probability of the country pair to receive the treatment conditional on the observable characteristics of the pair. The alternative NNM estimator adopts the technique of matching with replacement, allowing each country pair to be used as a match more than once in order to form the control group. Compared to the most common matching alternatives, the latter has the advantage of relying on a more precise matching procedure (since it is not based on a single reference indicator as in the propensity score). Since this approach makes a more intensive use of the information set of the panel it increases the goodness of the matching outcome (Baier and Bergstrand, 2009), although it has an additional cost in managing the high dimensionality of the data.

Specifically, assuming TF(1) denotes the value of trade between two countries with a Currency Union (CU) and TF(0) the value of trade between two similar countries without it, the NNM-ATE estimator is defined as follows:

$$ATE_M = \frac{1}{N}\sum_{i=1}^{N}[TF_i^*(1) - TF_i^*(0)] \qquad [1]$$

where M stands for the number of matches per unit and N for the number of country pairs. The NNM matching estimator imputes the missing potential trade flows using the average outcomes for the m_{th} closest unit – in terms of values for the covariates - to unit i among units j (i.e., units with opposite treatment to unit i) as follows:

$$TF_i^*(0) = \begin{cases} TF_i, & if\ CU_i = 0 \\ \frac{1}{M}\sum_{j\in J_M(i)} TF_j, & if\ CU_i = 1 \end{cases} \qquad [2]$$

and

$$TF_i^*(1) = \begin{cases} \frac{1}{M}\sum_{j\in J_M(i)} TF_j, & if\ CU_i = 0 \\ TF_i, & if\ CU_i = 1 \end{cases} \qquad [3]$$

where $J_M\ (i)$ denotes the set of indices for the first M matches for unit i.

Consistently, the ATT estimator is derived as follows:

$$ATT_M = \frac{1}{N} \sum_{CU_{i=1}} [TF_i - TF_i^*(0)] \qquad [4]$$

Since the number of matches increases with the sample size, there is little gain from using more than 3-4 matches, Hence, in this exercise we adopt the nearest three neighbours matching estimator. [7] There are three assumptions to consider when applying both these matching techniques. The key assumption is the so-called "unconfoundedness" or "selection on observable" which implies that conditional on observable characteristics, the treatment can be considered random. As proposed by the literature, we take advantage of the theory underling the gravity trade relationship for selecting the covariates to use in the matching procedure (Baier and Bergstrand, 2009; Montalbano and Nenci, 2014; Saia, 2017). In particular, gravity literature suggests that bilateral trade flows are dependent on the economic size of the countries (represented by GDPs), distance and some factors related to geographical, cultural and institutional proximity (such as common border and common language). In section 5 we provide evidence that using these covariates this first assumption can be considered satisfied. Another key assumption is the so-called "overlap" assumption, which implies that the sample should be large enough to include both treated and untreated observations. The use of the complete WIOD dataset ensures that this assumption is not violated in our case since it covers all the Eurozone members and a large number of non-member countries. [8] A third key assumption is the stable-unit-treatment-value assumption (SUTVA), which includes simultaneously the following two hypotheses: (i) the "unique treatment assumption," which means that the treatment is identical for each treated observation; (ii) the "non-interference assumption," that is, the bilateral trade between two treated countries (two Eurozone members) does not influence the trade of the untreated pairs. Both assumptions are not violated in the case at hand. Concerning the Eurozone membership, it is planned as a standard process for all treated country-pairs. As for the latter assumption, the empirical literature provides strong evidence of the absence of trade diversion in the case of the EMU process (Baldwin, 2006; Baldwin et al, 2008; Esposito, 2016).

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[7] Three matches seem to include sufficient information without matching unlike individuals and there is little gain from using more matches (Abadie et al., 2004).

[8] Baldwin at al. (2008) stress that the cleanest definition of the control group is represented by the members of the EU that are not inside the Eurozone. This because they share the implementation of several economic, regulatory and institutional measures. However, in principle, the EU members that do not take part in the Eurozone actually do not satisfy the pre-requisites to be included (with the relevant exception of the beneficiaries of the "opting out" clause) where this could be not necessarily the case for some of the non-EU members. Conversely, using the broader strategy means to implicitly assume that the unobserved factors influencing non-EU countries' bilateral trade have the same distribution as those influencing bilateral trade between EU countries. Considering that both the positions have pros and cons in implementing the matching exercise, we follow the suggestions of Baldwin et al. (2008) by presenting a sensitivity test using a sample restricted to EU member countries (see section 6).

In a second step, we also estimate the changes in outcomes for the treatment groups by presenting a combined NNM and Difference-In-Difference (NNM-DID) exercise in order to take advantage of the longitudinal dimension of the data. This lets us to simultaneously control for selection on observables and on fixed unobserved variables that could explain the difference in outcomes between treated and untreated country pairs. The difference-in-differences approach uses the before-after difference among the comparison group as a counterfactual for the before-after difference in the treatment group. In particular, as a first NNM-DID exercise we compare the outcome trends between the treated country pairs and the matched country pairs, using the average of two periods, pre and post treatment respectively as follows.:

$$DD = [(TF(1)|CU = 1) - (TF(0)|CU = 1)] - [(TF(1)|CU = 0) - (TF(0)|CU = 0)] \qquad [5]$$

where CU_i is the usual binary variable denoting EMU membership taking the value 1 for beneficiaries, and 0 for non beneficiaries. We provide also a second NNM-DID estimator by looking at the "within transformation" of the outcomes for the complete time span of the dataset (1995-2011), taking full advantage of the entire longitudinal dimension of the panel, as follows:

$$TF_{igt} = \beta_1 CU_i + \beta_2 t + \delta CU_i t + \alpha_g + \theta_t + \varepsilon_{igt} \qquad [6]$$

where *t* constitutes a binary variable taking the value of 1 for observations after the treatment. β1, β2, and δ are the regression coefficients to be estimated. α_g is a time-invariant group-level fixed effect capturing differences between the treatment and comparison group that are time-invariant. θ*t* is the time-invariant fixed effect capturing constant effects related to the each period. ε*igt* is the error term.

Although the DID approach accounts for unobservable time-invariant characteristics, it does not eliminate the unobservable differences between the treatment and control groups that change over time. Therefore, to perform this exercise we have to verify also the assumption that the outcomes have parallel trends between the treatment and control groups in the absence of treatment.

Finally, we repeat the NNM and the first NNM-DID exercises for the value added components taken as shares of gross exports in order to have a more clear evidence of the euro's effect on the fragmentation of production within the Eurozone and the productive linkages between its members countries.

4. Data description and sources

Trade data in value added are taken from the WIOD dataset (2013 release) which covers 40 countries and 35 sectors of activity (2-digit, according to the ISIC nomenclature rev. 3) for the years 1995-2011[9]. Since each country is considered as both exporter and importer, we have a panel of 1,482 (39*38) country pairs[10] in each year: the total number of observations in our panel is 25,194 (1482*17 years) .

Our outcome variables are the nominal value of annual bilateral gross exports as well as their value added components, measured both as gross exports' share and in absolute values (millions of current US dollars). The value added components of the bilateral gross export flows are derived by applying the methodology recently proposed by Wang et al. (2013)[11]. In particular, our analysis focuses on the two major value added components of gross exports, i.e. domestic value added (DVA) and foreign value added (FVA), together with the indirect value added component (INDIRECT). At bilateral level, DVA is the value added generated in the exporting country and destined for direct importing partners or third countries. More specifically, the decomposition by Wang et al. (2013) adopts a backward perspective, that is DVA in sector j gross exports summarizes all the backward linkages across upstream sectors that are suppliers of intermediate inputs to sector j and can include value added from all home supplier sectors. This approach allows to better capture the domestic supply networks of specific sectors because the DVA in sector j gross exports synthesizes the production linkages within the home country and the contribution of all upstream domestic sectors to the production of sector j's exports. In other words, it measures the full amount of the domestic factors that the national productive system embodies in those sectoral exports. FVA is foreign value added of intermediate inputs imported from abroad and embodied in the country's gross exports, which measure the dependence of country's exports on foreign inputs. Finally, within DVA, the INDIRECT component captures the domestic value added in intermediate goods re-exported by the direct importer to other foreign countries, that can thus be seen as a good proxy for joint participation of the bilateral trade partners in a global production network. Indeed, this component contains the exporter's value added that passes through the direct importer for a (or

[9] For a complete description of the database and its construction, see Timmer (ed., 2012). In November 2016, a new version of the dataset was made available which covers more countries (43) and sectors (58) for the period 2000-2014. Since it does not include data for the pre-euro period, this essay relies on the 2013 release. Unfortunately, due to different construction criteria, the 2016 release is not directly comparable with the previous one. Therefore, the two releases cannot be merged to create a new dataset for the years 1995-2014.

[10] Luxembourg is generally considered an outlier in trade analysis. As a precaution, we exclude this country from our empirical analysis.

[11] The work by Wang et al. (2013) proposes a detailed decomposition of trade flows at the sector, bilateral or bilateral sector level. Gross exports are disentangle into sixteen components that can be ascribed to four main components: domestic value added, returned domestic value added, foreign value added and pure double counting. See Wang et al. (2013) for a schematic outline of the decomposition framework and its detailed algebraic derivation.

some) stage(s) of production before reaching third countries in the form of intermediate or final goods[12].

In our first matching exercises, without longitudinal dimension, the outcome variable is alternatively the average value of bilateral gross exports or their value added components in the period 2004-2006. This to assess the impact of the treatment after some years since the adoption of the euro[13] and smoothing the value of the outcome variables to reduce possible bias due to annual anomalies[14]. Then, when we perform the analysis by taking advantage of the longitudinal dimension of the panel, we look first at the difference of the outcome variables in the period 2002-06 (post-treatment) with the 1995-1998 average (pre-treatment value) and then we perform a within transformation of the outcome variables for the entire period of observations.

Concerning the pre-treatment covariates, data on countries' GDP are taken from the World Development Indicators database of the World Bank. Distance and other economic geography and cultural tie variables are taken from the CEPII Gravity Dataset. In this case, we use the first year of the dataset, 1995, as the year of reference for all covariates.

Our treatment variable is the EURO dummy variable. It starts from 1999 (when the conversion rates between the euro and the currencies of the participating members states were irrevocably fixed between 11 out of 15 EU Member States) and takes the value of 1 when both countries adopt the euro at time t, and zero otherwise.[15] Since the WIOD dataset (2013 release) covers the period 1995-2011, this analysis ends in 2011 with a Eurozone of 17 members. [16]

5. Empirical outcomes

To test the "selection on observable" assumption, figures 1 and 2 compare the Kernel density function of the main gravity equation covariates, i.e. GDPs and distance, respectively, for the

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[12] The methodology by Wang et al. (2013) allows the pure double-counted items to be separated from the main value added components. Thus, the components used in this analysis are net of double counting items which are registered separately.

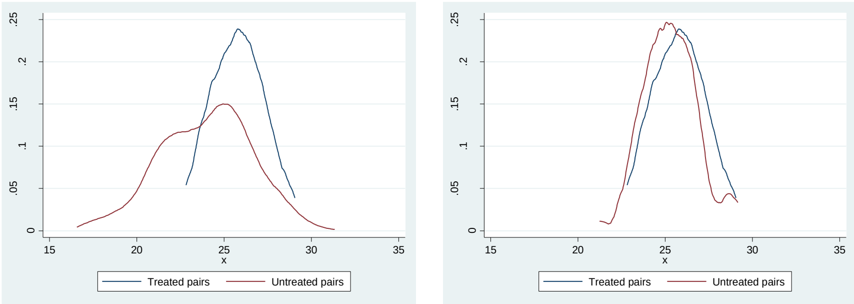
[13] Generally, a lag of about 5 years in the outcome is considered adequate in the policy evaluation literature. When 2002 is considered as a treatment year, we choose the period 2005-2007 to obtain the value of the outcome in order to avoid bias due to the effect of the economic crisis started in 2008.

[14] In the sensitivity analysis (section 6), we also perform the analysis by using single years (2004, 2006). The results, do not show significant differences.

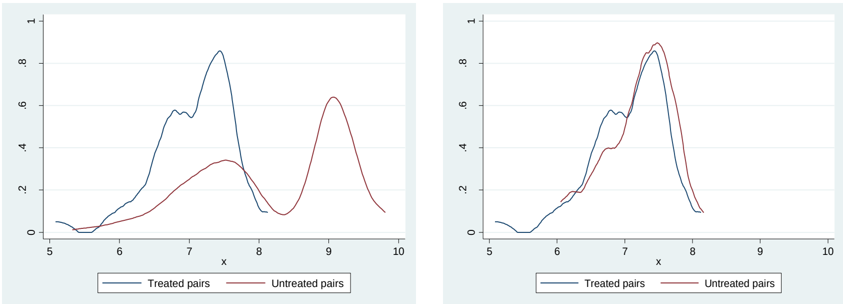
[15] For sensitivity purposes the same exercise with a EURO dummy starting from 2002, when euro banknotes and coins were introduced as legal tender and the "transition period" ended is presented in section 6.

[16] The euro was launched on 1 January 1999 and from then until December 2000, the Eurozone was a monetary union between 11 out of 15 EU member States (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain). On January 2001, Greece became the 12th member of the Eurozone. Since January 2002, the Eurozone has also become a currency union with the introduction of euro banknotes and coins as legal tender. Slovenia joined in 2007, followed by Cyprus and Malta in 2008, Slovakia in 2009, Estonia in 2011, Latvia in 2014 and Lithuania in 2015.

treated and untreated country pairs pre and post matching procedure[17]. These figures show that the post-matching distributions are more similar than the corresponding pre-matching distributions.



<u>Figure 1</u> Sum of logs of GDPs for bilateral pairs, pre and post A-I matching - complete dataset



<u>Figure 2</u> Logs of distance for bilateral pairs, pre and post AI matching - complete dataset

Tables 1 and 2 present the results of both PSM and NNM matching exercise using as outcome variable both gross exports and their trade in value added components.

- Table 1 presents the average treatment effects of euro on trade flows in absolute values in the period 2004-2006. ATE is positive both for gross exports and for their trade in value added components. This estimated impact is significant and even “larger” than previous empirical assessments: for instance, total gross bilateral exports show a jump of about 200% ($e^{1.0979}$-1) in the period 2004-2006 with respect to the pre-euro period. This ATE effect is even higher for the value added components of exports, except for DVA.
- This larger effect is not unexpected at least for two reasons: (i) matching techniques let us match only similar pairs - according to a set of observed characteristics - thus reducing the traditional bias in panel estimates when treated pairs are compared with all the other units in the sample; (ii) relaxing the assumption of linearity lets us better approximate the true relationship between the euro and trade flows and detect its causal impact by avoiding the constraints of the use of

[17] The year of treatment is 1999. The same pattern holds for other covariates, as well. For brevity’s sake, we do not report all graphs, but these are available on request.

parametric “gravity-like” estimates which prove to be - at the current state of the empirical literature - unable to include all the relevant multilateral effects of trade in parts and components.

- The average euro’s trade effect within the Eurozone countries (ATT) in the same period is also positive and significant when assessed using NNM (whereas it is not significant using PSM). The magnitude of the effect is lower than the ATE, although again higher for the value added components, except DVA. These first findings support the common wisdom of the euro’s positive effect on gross bilateral trade between Eurozone member states
- Table 2 complements the above results by taking advantage of the longitudinal dimension of the data and estimating the ATT on the changes in outcomes for the treatment group, by combining NNM and DID techniques.
- Figure 3 shows the validity of the underlying assumption of parallel trends to be assessed by comparing the trends of the log of total gross exports[18] for the treatment and control groups before the treatment (1995-1998 period).

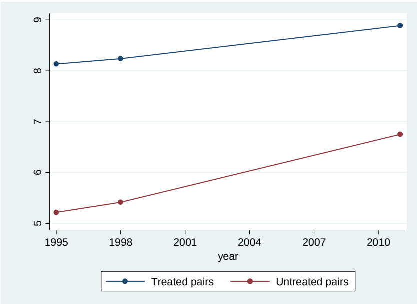


Figure 3 Outcome trends - complete dataset

- We present two alternative outcomes of the NNM-DID exercise: the first provides the double difference in trade flows (gross exports and their trade in value added components) between matched observations by comparing the changes in trade flows between two periods: pre and post euro adoption; the second one provides the same double difference between matched observations by looking at the “within transformation” of same trade flows for the entire period. The results show consistently a negative change in trade flows among euro member countries with respect to their matched untreated counterfactuals (a negative ATT coefficient). Thus, if we look at changes in trade flows the hypothesis of a euro positive effects for Eurozone member states seems to be less convincing. This is confirmed also when we extend our analysis further than only the period 2004-06 and look at the entire period under analysis. The same findings

[18] The same holds for other dependent variables in value added terms, as well. For the sake of brevity, we do not report all graphs, but these are available on request.

extend also to the value added components of exports. However, it is worth recalling here that the absolute values of the trade in value added components of exports basically follow the trend of gross exports. Further insights can be derived looking at the evolution of the trade in value added components as shares of total exports.

- Table 3 presents the NNM and NNM-DID exercises only for the value added components taken as shares of total exports. The NNM exercise shows that ATT is positive and significant only in the case of the DVA_INTrex component, whereas it is not significant for the other trade in value added components. This seems to underline that although the registered negative changes, the share of the domestic value added in intermediate goods re-exported by the direct importer to other foreign countries increases in the case of the Eurozone countries compared to their matched counterfactual. This again seems to support the hypothesis of the presence of a process of fragmentation of production within the Eurozone members after the adoption of the euro. However, when we move to the NNM-DID exercise, it is apparent that the changes in DVA_INTrex component in the post-euro period with respect to the pre-euro period has been indeed negative for the Eurozone countries with respect to their matched counterfactuals. The trade in value added component that actually increased in changes after the euro adoption for the Eurozone members is exclusively the domestic value added destined to direct importing partners or third countries (DVA).

6. Sensitivity

According to Baldwin et al. (2008), it is more appropriate to use a control group which is composed by the EU member countries that did not join the Eurozone in 1999 since it accounts for unobservable factors related to the institutional characteristics of the EU integration. Figures 3 and 4 show that applying the NNM procedure to this restricted dataset, provides less balanced outcomes. In addition, such restricted dataset includes a small number of untreated observations, with the risk of violating the "overlap" assumption. All these caveats considered, the results of both PSM and NNM matching estimates on the restricted dataset are reported in Table 4. It confirms that the use of value added components do not change the sign of the euro's effect.

Another robustness check is to adopt 2002 as the treatment year. In this case the average

outcome values are calculated for the period 2005-2007. Table 5 shows that in this case the coefficients of both ATE and ATT are lower in the magnitude compared with Tables 1 and for the ATT are not more significant for all dependent variables. A preliminary explanation could be in line with some recent analyses (De Sousa, 2012; Rotili, 2014) that observe how the positive trade effect of the euro was concentrated in the first years after its introduction. This means that the euro could have been a driver for the growth of bilateral exports among Eurozone members, but its boost to trade seems to have been gradually reduced. Finally, a third robustness check is to look at our matching estimates using the value of the exports in a single year (Table 6).

7. Conclusions

This work joins the debate on the euro's effect on trade by providing two original contributions. First, it innovates the previous literature that assessed the euro impact mainly through gravity analyses (see the surveys by Baldwin et al., 2008, Head and Mayer, 2014, and lastly Rose, 2016) by applying non-parametric matching techniques that control for nonlinearity-with-self selection. Second, it assesses the euro's effect on the value added components of gross exports and presents tentative interpretations of the divergences between results using value added rather than gross data. Preliminary results show that, differently from many gravity assessments of the euro effects, our matching estimates show a positive effect of the euro on bilateral trade and this result extends also to the outcomes that takes into account the fragmentation of production in the Eurozone. However, if we look at changes in trade flows the hypothesis of a euro positive effect is less convincing. Whereas our aim is not to provide clear-cut conclusions on the old debate about the euro's impact on bilateral trade, we strongly believe that our results - and the provided set of robustness checks - surely contribute to enhance our understanding of the euro's impact and its policy implications

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Table 1 **PSM and NMM estimates (outcomes in absolute values)**

	PSM				NNM			
	Gross exports	DVA	FVA	DVA_INTrex	Gross exports	DVA	FVA	DVA_INTrex
ATE EURO	0.2955**	0.288***	0.4375*	0.4180***	1.0979***	1.0950***	1.1672***	1.3177***
	0.116	*0.096*	*0.248*	*0.144*	*0.085*	*0.079*	*0.119*	*0.096*
ATT EURO	-0.0447	-0.0726	0.066	0.0242	0.2810***	0.2700***	0.3159***	0.4116***
	0.145	*0.153*	*0.175*	*0.165*	*0.109*	*0.106*	*0.116*	*0.118*
Number of obs	1482	1482	1482	1482	1482	1482	1482	1482
Control	1392	1392	1392	1392	1392	1392	1392	1392
Treated	90	90	90	90	90	90	90	90

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; (Robust) SEs in italics.

Table 2 **NNM-DID estimates (outcomes in absolute values)**

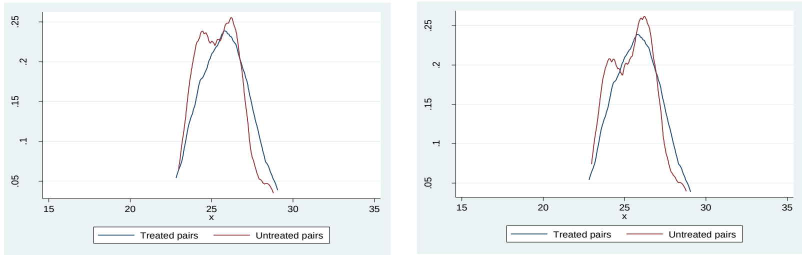
	NNM-DID pre-post diff				NNM-DID within transformation			
	Gross exports	DVA	FVA	DVA_INTrex	Gross exports	DVA	FVA	DVA_INTrex
ATT EURO	-0.3375***	-0.3128***	-0.3410***	-0.4443***	-0.2584***	-0.2439***	-0.3268***	-0.2864***
	0.0444	*0.0432*	*0.0517*	*0.0508*	*0.0847*	*0.0869*	*0.0845*	*0.1005*
Number of obs	360	360	360	360	6120	6120	6120	6120

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; (Robust) SEs in italics.

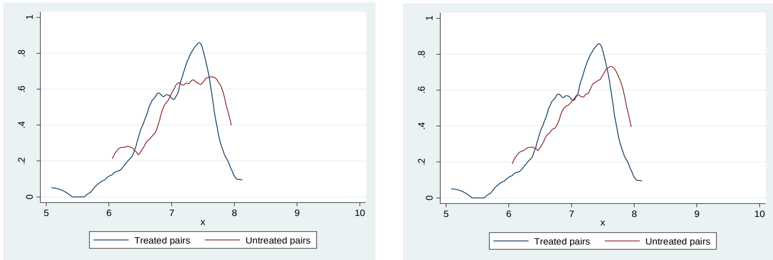
Table 3 **NNM and NNM-DID estimates (outcomes in shares)**

	NNM period 2004-2006			NNM-DID		
	DVA	FVA	DVA_INTrex	DVA	FVA	DVA_INTrex
ATT EURO	0.0165***	-0.0062**	-0.0167***	.0112754**	-.0088389**	.0049775
	0.0042	*0.0036*	*0.0050*	*.005484*	*.0047519*	*.0064257*
Number of obs	360	360	360	6120	6120	6120

Notes: *, ** and * denote significance at the 1%, 5% and 10% levels, respectively; (Robust) SEs in italics.**



<u>Figure 3</u> Sum of logs of GDPs for bilateral pairs, pre and post A-I matching - restricted dataset



<u>Figure 4</u> Logs of distance for bilateral pairs, pre and post AI matching - restricted dataset

<u>Table 4</u> PSM and NMM estimates - restricted dataset

	PSM				NNM			
	Gross exports	DVA	FVA	DVA_INTrex	Gross exports	DVA	FVA	DVA_INTrex
ATE EURO	0.4658***	0.4035**	0.5867***	0.5365***	0.2043*	0.1556	1.2727**	0.3395***
	0.178	*0.171*	*0.218*	*0.1623*	*0.102*	*0.099*	*0.119*	*0.111*
ATT EURO	0.5966***	0.5223**	0.7391***	0.6978***	0.3637***	0.3119***	0.4279***	0.4965***
	0.231	*0.225*	*0.27*	*0.205*	*0.108*	*0.106*	*0.125*	*0.119*
Number of obs	182	182	182	182	182	182	182	182
Treated	92	92	92	92	90	90	90	90

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; (Robust) SEs in *italics*.

Table 5 PSM and NMM estimates - Year of treatment: 2002

	PSM				NNM			
	Gross exports	DVA	FVA	DVA_INTrex	Gross exports	DVA	FVA	DVA_INTrex
ATE EURO	0.1819	0.1924	0.3257	0.1423	0.9037***	0.9012***	0.9861***	1.0453***
	0.145	*0.124*	*0.286*	*0.146*	*0.122*	*0.079*	*0.152*	*0.143*
ATT EURO	-0.0004	-0.0219	0.1346	-0.0970	0.0241	0.0222	0.0473	0.0780
	0.138	*0.146*	*0.143*	*0.163*	*0.109*	*0.098*	*0.107*	*0.111*
Number of obs	1482	1482	1482	1482	1473	1473	1482	1482
Treated	90	90	90	90	90	90	90	90

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively; (Robust) SEs in *italics*.

Table 6 NMM estimates - Year of treatment: 1999 - Outcome: exports flows in 2004 or in 2006

	2004				2006			
	Gross exports	DVA	FVA	DVA_INTrex	Gross exports	DVA	FVA	DVA_INTrex
ATE EURO	1.1819***	1.1814***	1.2316***	1.3982***	1.0415***	1.0404***	1.1180***	1.2625***
	0.280	*0.282*	*0.281*	*0.294*	*0.280*	*0.274*	*0.273*	*0.287*
ATT EURO	0.3374***	0.3293***	0.3537***	0.4798***	0.2347**	0.2243**	0.2744**	0.3537***
	0.113	*0.111*	*0.119*	*0.125*	*0.113*	*0.111*	*0.116*	*0.128*
Number of obs	1482	1482	1482	1482	1482	1482	1482	1482
Treated	90	90	90	90	90	90	90	90

Notes: *** denotes significance at the 1% level; (Robust) SEs in *italics*.