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The Determinants of Euro Invoicing in Extra-EU Exports

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Abstract

I empirically analyse the determinants of euro invoicing with a panel data regression. This study makes use of new data, resulting in a homogenous dataset for 27 EU countries. Looking at various macroeconomic variables, I find that the main determinants of euro invoicing are membership of the Euro Area and the share of manufactured goods in total extra-EU exports, which both positively influence the percentage of extra-EU exports that is invoiced in euro. A higher exchange rate volatility or a higher inflation differential make euro invoicing less likely, which may indicate that the euro is not often used as vehicle currency.

I. INTRODUCTION

The introduction of the euro in 1999 created a new international unit of account. It provided countries with a new invoicing currency for international trade, as an alternative for their (abandoned) domestic currency or the US dollar. When exporting goods, firms have three options in terms of choice of invoicing currency. They can invoice in the currency of their home country, in the currency of the country of the buyer, or in a widely used third currency (such as the US dollar), which is then called a vehicle currency. The choice of invoicing currency has relevant implications for both firms and the international economy. Firms involved in international trade see their profits affected by the invoicing currency chosen. Invoicing in their home currency provides exporting firms with price certainty but causes quantity uncertainty at the same time, as the exchange rate risk shifts to the demand side. Furthermore, the choice of invoicing currency also affects the degree to which countries' business cycles are synchronized, which has implications for monetary policy. When firms of country A use the currency of country B in invoicing its exports, country A's economy is more sensitive to exchange rate fluctuations. This amplifies the business cycle synchronization between country A and B (McKinnon & Schnabl, 2002). On the other hand, countries whose firms invoice their exports in their home currency are more effective at implementing domestic monetary policy, since they suffer less spillover from foreign monetary policy shocks (Zhang, 2019).

There is not much empirical research on the currency of invoicing in international trade, and even fewer on the euro as invoicing currency specifically. This is mainly due to the scarcity of data on invoicing currencies. Kamps (2006) wrote the most comprehensive paper on the euro as invoicing currency in international trade. For this research, Kamps collected the data on invoicing currencies from various sources, which led to missing values for some countries and an unbalanced dataset. Since 2010 however, the European Union (EU) requires its member states to keep track of invoicing statistics (Commission Regulation (EU) No 113/2010). All EU member states must report to Eurostat the percentage of extra-EU trade (imports and exports) that is invoiced in euro. This data provides an opportunity to conduct a new research on the use of the euro as invoicing currency. The invoicing data show large differences in the use of the euro as invoicing currency in extra-EU trade between EU countries. For example, Slovakia invoiced 88.1 percent of its extra-EU exports in euro in 2012, while the UK only invoiced 3.5 percent of its extra-EU exports in euro in the same year. This paper will focus on explaining these differences empirically. My research question is:

What are the main reasons for the differences between EU countries in their percentage of extra-EU exports that is invoiced in euro in the period 2010-2016?

I have confined the research question to extra-EU exports and do not study extra-EU imports. This research is uses data of the period from 2010 until 2016. I will look at invoicing currencies in 27 EU countries. This includes all the current members of the EU, excluding Croatia, because for this country not all relevant data is available since it only joined the EU in 2013. The term 'EU countries' or 'EU member states' will be used interchangeably throughout this paper to denote all EU countries excluding Croatia. Within the EU, a distinction will be made between members of the Euro Area (EA), and countries that are not yet a member of the EA. The EU countries that are a member of the EA will be denoted with 'EA countries', and the EU member states that are not part of the Euro Area will be denoted with 'non-EA countries' throughout this paper. A list of countries included in this research can be found in the appendix.

I will look into the determinants of invoicing extra-EU exports in euro, including the effect of being an EA member. The US dollar is still the most used vehicle currency, and a country's trade with the US is more likely to be invoiced in US dollars. Commodities such as oil are traded on the world market and more often invoiced in US dollars as well. This may be an issue when estimating the determinants of euro invoicing, and therefore these effects will also be taken into account in this paper, by looking at the effect of the exports of manufactured goods. Due to data limitations, I will not be able to shed light on the influence of industry features, such as specific sectors, on the choice of invoicing currency.

Since this paper only focuses on extra-EU exports, the term 'exports' will also be used to denote extra-EU exports throughout this paper. Moreover, the "euro invoicing percentage" refers to the percentage of extra-EU exports that is invoiced in euro.

This paper will build on the work of Kamps (2006). More than a decade has passed since her research, and hence this paper may give new insights in the determinants of the choice of invoicing currency. The EU and the Euro Area have substantially grown in size and suffered major economic crises since 2006, which may have influenced the role of the euro in international trade. Furthermore, I make use of a new, homogenous dataset, which may lead to improved results. This paper allows for a comparison in the development of the determinants of euro invoicing since 2006, and in that way it contributes to the existing literature.

The social relevance lies in the fact that the findings may lead to new valuable insights for firms or policy makers, when deciding on the choice of invoicing currency or monetary policy respectively.

I find that the main determinants of euro invoicing are membership of the Euro Area and the share of manufactured goods in total extra-EU exports, which both positively influence the percentage of extra-EU exports that is invoiced in euro. Exchange rate volatility and the inflation differential have a negative effect, which may indicate that the euro is not often used as vehicle currency. The effect of the share of US exports in total extra-EU exports is insignificant, as is the effect of a country's international market power.

The remainder of this paper will be structured as follows. In section II, the theoretical framework is laid out. Section III describes the data and methodology used and section IV discusses the results. The last section concludes and reviews the implications and limitations of this research.

II. THEORETICAL FRAMEWORK

In this section, I will analyse the theoretical and empirical literature on the choice of invoicing currency. I will also formulate my hypotheses.

There are three different options when choosing an invoicing currency. An exporter can choose to price his products in his own currency, which is called producer currency pricing (PCP). This creates price certainty but also demand uncertainty, as the buyers bear the risk of fluctuating exchange rates (Baron, 1976). When products are priced in the currency of the buyer, it is local currency pricing (LCP). For the exporter, LCP has the issue of price uncertainty, as the price of his goods in his own currency may fluctuate. It has the advantage of demand certainty, since buyers face constant prices. Whether PCP or LCP is more advantageous for an exporter depends on various micro- and macroeconomic factors, such as the demand and cost structure of the firm and the price sensitivity of the goods sold (McKinnon, 1979). Viaene and De Vries (1992) constructed a model in which exporters and importers bargain over the invoice currency. They assume that the domestic currency is preferred and find that possible reasons for the dominance of the exporter's currency are either the exporter's first mover advantage or the monopoly power of the exporter. Donnenfeld and Zilcha (1991) modelled a firm's choice of invoicing currency and found that exporters that have a concave revenue curve

in the foreign price should choose LCP. PCP is, under flexible price adjustment, optimal if the variance of the exporter's currency is less than the variance of the local currency, according to Engel (2002). Devereux, Engel and Storegaard (2003) used a two-country dynamic general equilibrium model with sticky prices. They concluded that both importing and exporting firms have an incentive to price in the currency of the country with the lowest monetary volatility.

The third and final choice for the invoicing currency is choosing a currency that is neither the exporter's nor the importer's home currency. This is called vehicle currency pricing (VCP). VCP is preferred if the vehicle currency has low volatility with respect to the bilateral exchange rate of the exporter and importer (Friberg, 1997). For homogenous goods and primary goods, a vehicle currency with low transaction costs is preferred, according to McKinsey (1979). Bacchetta and Van Wincoop (2002) analyse the optimal pricing strategy of exporters. They find that exporters minimize demand risk by invoicing in the same currency as the average competitor. They argue that a monetary union can be regarded as one country with respect to the invoicing currency, since all members use the same currency.

To sum up the theoretical literature, most authors seem to agree that minimizing risk (which often translates into monetary volatility) is one of the main reasons for choosing a particular invoicing currency. Firms from countries with high exchange rate volatility will therefore tend to use LCP or VCP. The optimal pricing strategy for a firm depends however also on industry features. The results of the empirical studies, which are described below, are mostly in line with these conclusions.

Donnenfeld and Haug (2003) conducted an econometric study on Canadian import invoicing. They found that firms from countries that are large compared to Canada are less likely to use vehicle currencies, and more likely to price in their own currency. Kamps (2006) studied the development of the euro as invoicing currency empirically. She concluded that the share of exports invoiced in euro has increased when compared to the share of exports invoiced legacy currencies (the currencies formerly used in EA countries). This increase came at the cost of the US dollar and local currencies. She finds that significant determinants that positively influence the share of euro invoicing are being a part of or a candidate for the EU, whether a country has pegged its currency against the euro, and the market power of a country's economy (a country's exports as a share of world exports). Kamps finds that a positive relationship exists between a country's exchange rate volatility relative to the euro and the share of its trade invoiced in euro, which is a confirmation of the theoretical expectations that firms tend to

choose the currency with the lowest volatility. Although the US dollar is still the dominant vehicle currency, the author sees indications for an increased role of the euro.

Goldberg and Tille (2008) conducted an empirical research on the use of vehicle currencies in international trade with a dataset covering 24 countries, and mainly focus on the role of the US dollar. They find that one of the main determinants for the choice of invoicing currency is country size – trade is more likely to be invoiced in the currency of the larger country. They note the Euro Area should be seen as one large country in this respect. Goldberg and Tille also stress the importance of the US dollar in international trade. They find that trade with the United States is primarily invoiced in US dollars, and also that homogeneous goods are more likely to be invoiced in US dollars, which is one of the reasons why the US dollar is the most prominent vehicle currency. Lastly, they find that industry features also play an important role for the choice of invoicing currency, which is in line with the theoretical literature.

Invoicing in your own currency is beneficial for both importers and exporters, according to Papaioannou and Portes (2008). In their empirical analysis, they find that pricing in your own currency offers exchange rate stability and eliminates possible high costs in the foreign exchange market. Moreover, they conclude that the invoicing currency is negatively related to transaction costs: high volatility, high inflation and underdeveloped capital markets have a negative effect on a firm's profits. This is a reason for the leading position of the US dollar as invoicing currency. The United States have a history of low inflation, developed foreign exchange markets and low exchange rate volatility, and hence the US dollar is a currency with low transaction costs. The authors see the euro as an attractive alternative for the US dollar as vehicle currency, as the euro shares the aspects which have made the US dollar so dominant.

Ligthart and Werner (2012) studied the impact of the euro on the choice of invoicing currency using a compositional multinomial logit model, analysing data on Norwegian imports. They find that Norway's trading partners use the euro more often than before the introduction, thus that the euro has led to more PCP in Euro Area countries. The main driver for the increase in PCP, and hence a determinant of euro invoicing, is the fall in inflation volatility. Ligthart and Werner further find that the size of the foreign exchange market and the invoicing share of the previous quarter positively affect the share of euro invoicing. The authors also note that the euro has overtaken the US dollar as the most used vehicle currency in Norway.

From the literature, it becomes clear that there are several important influencers of the choice of invoicing currency. Firstly, firms prefer to invoice in the currency of their home country. Countries in the Euro Area are therefore expected to see more exports invoiced in euro compared to non-EA countries. This gives rise to my first hypothesis, which states:

Being a member of the Euro Area significantly increases the share of extra-EU exports invoiced in euro.

Secondly, a major role is reserved for the US dollar, as the currency is dominant in trade with the United States and in commodity trade. The more an EU country exports to the United States, the less it is expected to invoice its exports in euro. My second hypothesis therefore states:

The share of a country's exports with the United States negatively influences the percentage of extra-EU exports invoiced in euro.

Thirdly, transaction costs are of importance for the choice of invoicing currency. Currencies from countries with deep financial markets are often less volatile, and these currencies are hence more often used as invoicing currency. Countries outside the Euro Area should for this reason be more likely to use the euro as vehicle currency if their currency exhibits high exchange rate volatility vis-à-vis the euro. My third hypothesis is therefore:

The exchange rate volatility of a currency vis-à-vis the euro has a positive effect on the share of extra-EU exports invoiced in euro.

Fourthly, industry features are of importance. Goods that are homogenous or easily substituted are more often invoiced in a vehicle currency. Unfortunately, invoicing data disaggregated at the industry level is not available, which makes a thorough analysis of the influence of industry features on the invoicing currency not possible at this moment. I will however include the effect of exporting manufactured goods in my analysis. According to Goldberg and Tille (2008), homogeneous goods are predominantly invoiced in a vehicle currency, which is mainly the US dollar. This implies that non-homogenous goods are more often invoiced in the domestic currency. Homogenous goods are mainly primary goods, including commodities such as oil, and manufactured goods are often non-homogenous. Therefore, manufactured goods are expected to be invoiced in euro relatively more, compared to the total number of goods. This expectation is also supported by Grassman's law, which (amongst other things) states that trade in manufactured goods between industrialized countries

is more often invoiced in the producer's currency (Grassman, 1973). My fourth hypothesis is hence:

Exporting relatively more manufactured goods increases the share of extra-EU exports invoiced in euro.

I will test these hypotheses empirically by regressing the share of extra-EU exports invoiced in euro with several explanatory variables. In the next section, I will further explain my choice of variables for this research.

III. DATA AND METHODOLOGY

3.1 Data

Data on invoicing currencies is very selectively available. At the moment of collection, the only easily accessible data is the percentage of euro used in extra-EU invoicing, measured biannually for all EU countries for the period 2010-2016. A value of 50, for instance, indicates that 50% of a country's extra-EU exports is invoiced in euro. The data has been obtained from Eurostat. Since this data is only available from 2010, this is the starting period of the dataset. The last measurement of invoicing was in 2016, which makes this year the final period. The invoicing data has been interpolated for the years 2011, 2013 and 2015 by using the average value of the preceding and the following year. An overview of the invoicing data per country can be found in the appendix. Although the interpolation allows for a larger dataset, it also means that a substantial part of the observations of my dependent variable are not actual data. For this reason, I will analyse the dataset without the interpolated values separately in the results section.

The reason why invoicing currency data has only started being measured in 2010 is because from that year, EU countries were obligated to compile invoicing currency statistics (Regulation (EU) No 113/2010). Croatia only became a member of the EU in 2013, and its invoicing data of before that year is not available. Therefore, Croatia has been dropped from the sample. Bilateral data on invoicing currency is not available. This makes distinguishing between the different invoicing methods (PCP, LCP and VCP) hard. For this reason, it is also not possible to consider industry features in this research. Furthermore, the invoicing data only considers trade of goods, which is why the service sector will not be studied in this paper.

The invoicing data has been obtained from a single source (Eurostat), whereas other papers such as Kamps (2006) collected data from various national statistics bureaus and central banks. My method has the advantage of a balanced and homogenous dataset. Each country has the same number of observations and the methods of measurement are the same for each country, which is expected to improve the reliability of the results. My dataset is however in some respects less detailed than that of Kamps (2006), as the numbers on invoicing currency are only reported biannually while some national agencies record annual invoicing statistics. It should be noted that not all national agencies have these statistics readily available, which is one of the reasons why there is a scarcity of papers on the topic of invoicing currencies.

This paper focusses on extra-EU exports, which is why, contrary to some other empirical papers on this topic, imports are not included. However, a clear difference in the determinants of export invoicing currency and import invoicing currency does not emerge from the literature – most papers, including Kamps (2006) find determinants for the invoicing currency used in international trade in general. Hence, although I am only considering one half of the international trade flows in this research, I expect that my results can be generalised from extra-EU trade exports to all (extra-EU) international trade.

An overview of all the variables used in this paper can be found in Table 3.1. As my first explanatory variable, I include the value of each country's extra-EU exports relative to world exports. This will capture a country's international market power. Market power is expected to be an essential determinant of euro invoicing, as firms from large countries are more likely to invoice in their own currency. The exports variable also captures the effect of a country's size.[1] Exports are more related to the choice of invoicing currency than GDP, which is why using relative exports as measurement of a country's market power and size is preferred. The data on the value of extra-EU exports has been obtained from Eurostat. The world exports data comes from the IMF Balance of Payments Statistics Yearbook and has been converted to euro using the yearly nominal exchange rate data obtained from Eurostat, which is the exchange rate I have used for all currency conversions. To capture the effect of exports to the US, which are often invoiced in dollars, I include each country's percentage of exports to the US. This data has been collected from the US Census Bureau and has been converted to euro.

[1] The correlation between GDP and the share of exports in world exports is 0.930. I also experimented with adding GDP to the regression analysis, but this did not change any of the results.

Table 3.1 Variables used

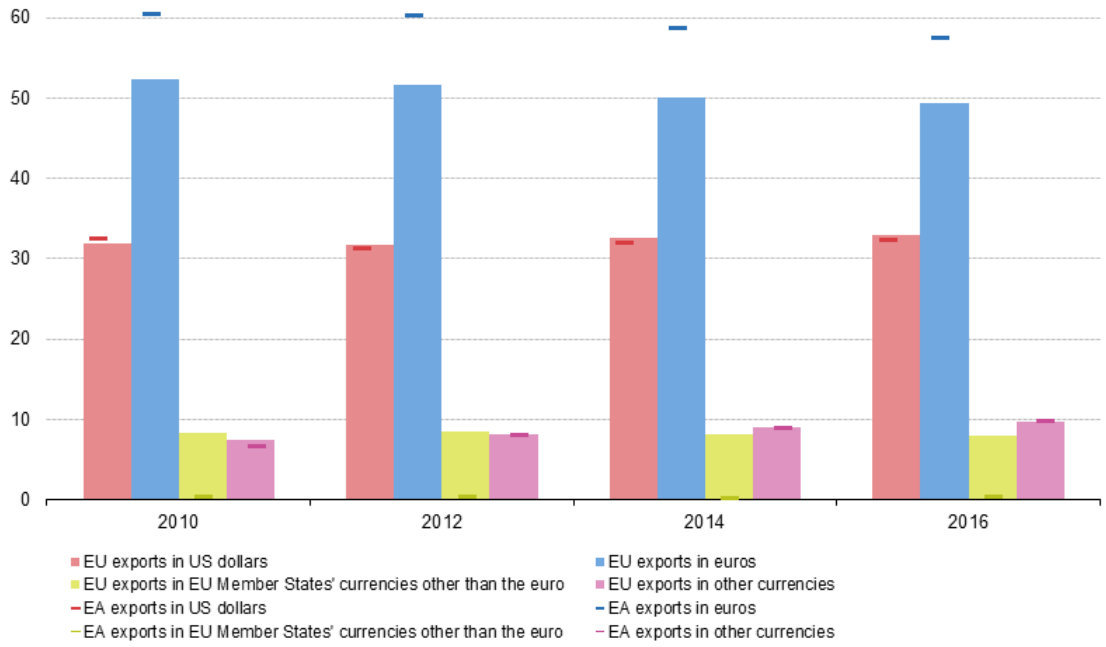
Variable	**Definition**	**Unit**	**Source**
$euroinv_{i,t}$	percentage of extra-EU exports that is invoiced in euro by country *i* at time *t*	percentage	Eurostat
$export_{i,t}$	share of country *i*'s extra-EU exports in world exports at time *t*	percentage	Eurostat and IMF BOPS Yearbook
$USshare_{i,t}$	share of extra-EU exports that country *i* exports to the US at time *t*	percentage	US Census Bureau
$euroarea_{i,t}$	1 when country *i* is a member of the Euro Area at time *t* 0 otherwise	dummy	europa.eu
$exratevol_{i,t}$	exchange rate volatility vis-à-vis the euro of the currency of country *i* at time *t*		Eurostat
$inflationdif_{i,t}$	inflation differential relative to the Euro Area of country *i* at time *t*		Eurostat
$manufshare_{i,t}$	share of manufactured goods in total extra-EU exports from country *i* at time *t*	percentage	Eurostat

A dummy is included that has value 1 if a country is a member of the Euro Area, and value 0 otherwise. This variable captures the effect of being a member of the monetary union. The exchange rate volatility is included to capture the effect of exchange rate risk for non-EA countries. The volatility is calculated for each year using a twelve-month moving average standard deviation, using the rate of change of the exchange rate. A detailed description of the calculations can be found in the appendix. Euro Area countries have an exchange rate volatility of zero, as do countries whose currency is pegged to the euro. To capture the monetary stability of the non-EA countries, I include the yearly inflation differential of these country relative to the Euro Area. The lower the inflation differential, the higher the monetary stability of a country relative to the EA. The inflation differential is calculated by subtracting the yearly inflation rate of the Euro Area from the inflation rate of each non-EA country. EA countries have an inflation differential of zero. The data for both variables is collected from Eurostat. A forward market is present for the currency of each country in my dataset. Hence, I cannot test the effect of a forward market on invoicing exports in euro. I do not include a dummy for countries that have pegged their currency to the euro, because it overlaps with the variables for exchange rate volatility and membership of the euro area. Lastly, I add a variable that captures the effect of manufactured goods, which are expected to be invoiced more in euro. This variable is calculated

by dividing the value of exports of manufactured goods by the value of total extra-EU exports for each country. A more detailed description of the data alterations can be found in the appendix.

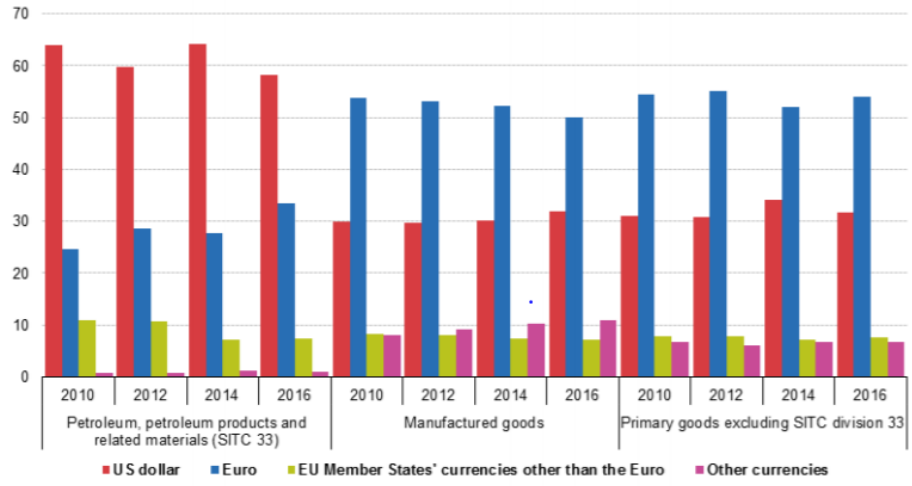
The alternative for invoicing in euro is for most countries mainly using the US dollar, or, if a country is not a member of the Euro Area, its domestic currency. This becomes clear from Figure 3.1. This figure also shows that total share of EU exports invoiced in euro has slightly declined over the last few years, from 51 percent in 2010 to 49 percent in 2016. However, EU member states belonging to the Euro Area invoice consistently more of their extra-EU exports in euro, ranging from 61 percent in 2010 to 58 percent in 2016. This is almost entirely due to the fact that non-EA members use their own currencies, as the share of extra-EU exports invoiced in US dollars is similar for both EA countries and non-EA countries.

Figure 3.1 Extra-EU export shares by invoicing currency, in %



Source: Eurostat. Note: EA is the Euro Area

Figure 3.2 Extra-EU export shares by invoicing currency and product group, in %



Source: Eurostat

Figure 3.2 shows that the currencies used in invoicing vary across product groups. As expected, petroleum products are substantially more invoiced in US dollars. This is one of the reasons why I include the share of manufactured exports in the model.

Table 3.2 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Unit
euroinv	189	51.1537	20.20342	3.2	88.1	percentage
export	189	.3507515	.5557197	.0024989	2.657847	percentage
USshare	189	15.87386	11.68974	17.45442	73.72577	percentage
euroarea	189	.6507937	.4779855	0	1	dummy
exratevol	189	.0037968	.0079981	0	.0377796	-
inflationdif	189	.1026455	.7543092	-2.8	4.5	-
manufshare	189	75.39332	15.47604	25.91733	97.66197	percentage

Note: observations are panel data – 27 EU countries over 7 years (2010-2016)

My dataset is panel data, as I have observations for different countries for a number of years. The dataset is highly balanced, as all variables have the same number of observations (189, which is 27 countries multiplied by 7 years). From the descriptive statistics in Table 3.2 it stands out that there are large differences in the share of exports invoiced in euro (*euroinv*). It ranges from 3.2% (UK 2016) to 88.1% (Slovakia 2012) in the dataset, with a mean of 51.2%. The value of extra-EU exports relative to world exports (denoted by *export*) also vary largely

across countries and time. This is because small countries such as Cyprus do not export much relative to the rest of the world, while the sample also includes Germany, which is one of the largest exporters in the world. About 65 percent of the countries in the sample is a member of the Euro Area. The share of extra-EU exports that goes to the United States (*USshare*) also varies across the countries, and particularly the share of exports of manufactured goods, which ranges from 1.5 to 75 percent. About 65% of the EU countries is also a member of the EA. The mean of the exchange rate volatility (*exratevol*) is rather low, but this is mainly due to the fact that most countries in the sample are either an EA member or have pegged their currency to the euro. The same goes for the inflation differential (*inflationdif*), which ranges from 2.8 percentage points less to 4.5 percent more than the inflation of the Euro Area. The share of manufactured goods in total extra-EU exports (*manufshare*) is on average about 75 percent. Again, large differences exist between the countries, as the variable ranges from 26 percent (Greece 2012) to 98 percent (Luxembourg 2013).

3.2 Methodology

As my dataset contains panel data, I estimate a panel model. In my model, I will attempt to explain the percentage of extra- EU exports that is invoiced in euro with the explanatory variables. The regression model is written down in equation 3.1.

$$euroinv\_tot_{i,t} = \beta_0 + \beta_1 export\_tot_{i,t} + \beta_2 USshare\_tot_{i,t} + \beta_3 euroarea_{i,t} + \beta_4 exratevol_{i,t} + \beta_5 inflationdif_{i,t} + \beta_6 manufshare_{i,t} + u_{i,t} \quad (3.1)$$

This is a regression model where the euro invoicing percentage of country *i* at time *t* is explained by the value of exports of country *i* as a percentage of world exports at time *t*, by country *i*'s exports to the US relative to its total extra-EU exports at time *t*, whether country *i* is a member of the euro area at time *t*, the exchange rate volatility of the currency of country *i* vis-à-vis the euro at time *t*, country *i*'s inflation differential with the euro area at time *t* and the share of extra-EU exports of country *i* at time *t* that are manufactured goods.

Based on the first hypothesis, the coefficient of the *euroarea* dummy is expected to be positive. A country that is a member of the eurozone should invoice more in euro. The second hypothesis implies that the coefficient of *USshare* and should be negative. According to the third hypothesis, the coefficient of exchange rate volatility is expected to be negative. Lastly, the fourth hypothesis expects the value of *manufshare* to be positive. Manufactured goods are expected to be invoiced in euro relatively more than other goods.

Firms from large countries are more likely to invoice in their own currency, and therefore the coefficient of *export* is expected to be positive. If a non-EA country exhibits a high inflation differential with the EU, this increases transaction costs for the use this country's home currency, and hence makes it more likely that firms will use the euro in international trade. The coefficient of *inflationdif* is therefore expected to be positive.

The data will be analysed using different panel data approaches, which are based on the research of Kamps (2006). One of them is the random effects model. It assumes that the there is no correlation between the predictors and the error term, in other words that there is no endogeneity. Another model is the fixed effects model, in which only time-varying effects are included. The assumptions for this model are less strict. The fixed effects model automatically corrects for all non-time-varying predictors, observed and unobserved. To test which model is appropriate, a Hausman test is performed. This tests whether there exists a systematic difference between the estimated coefficients of both models. The result of this test can be found in the appendix (Table A.1). The null hypothesis is rejected for the model of equation (3.1) (p=0.000). This means that the fixed effects model is preferred, which I thus use for my estimation. The fixed effects model looks at the variation of the variables within each country. It corrects for all time-invariant predictors, observed or unobserved. The modified Wald test (see appendix Table A.2) shows that heteroskedasticity is present in the model of equation (3.1) (p=0.000). Moreover, the Wooldridge test for autocorrelation shows that first-order autocorrelation is present in the dataset, for the model of equation (3.1) (p=0.000, see appendix Table A.3 for the results). To solve these problems, I use Driscroll-Kraay standard errors (Driscroll & Kraay, 1998; Hoechle, 2007). The maximum lag is set at two.[2]

I also tested for omitted variable bias by testing for time effects in the fixed effects model (see appendix Table A.4). This test showed that time effects are present (p=0.000). I will control for that by including dummies for each year.

To account for the heteroskedasticity and panel specific autocorrelation in another way, I also use a Prais-Winsten estimation. Here I include robust standard errors. In the Prais-Winsten estimation, time effects are not present (p=0.726). All my models are ordinary least squares.

When omitting the interpolated values of *euroinv*, i.e. only including the years 2010, 2012, 2014 and 2016, the specifications of the dataset with respect to heteroskedasticity, autocorrelation, and time effects remained the same. I therefore use the same fixed effects

[2] This is calculated by m(T)=floor[4(T/100)^(2/9)].

model with Driscoll-Kraay standard errors to analyse this data. It was not possible to conduct a Prais-Winsten estimation on the non-interpolated values.

IV. RESULS

The results of the estimation of the model of equation (3.1) are presented in Table 4.1. This model attempts to explain the variation in the percentage of total extra-EU exports that is invoiced in euro. The two methods used to estimate the coefficients are the fixed effects model with Driscroll-Kraay standard errors, and Prais-Winsten estimation. I have also included a fixed effects model where the interpolated values of *euroinv* are omitted, i.e. only for the years 2010, 2012, 2014 and 2016.

The dependent variable is expressed as percentage, meaning that the value of a coefficient denotes the percentage point impact of an increase of one in the respective variable on the euro invoicing percentage. I will first shed light on the first two columns of the regression table. The share of a country's exports relative to world exports does not have a significant effect (at the 5% level) on the percentage of euro invoicing in both the fixed effects model and the Prais-Winsten estimation. Moreover, the sign of the coefficients differs between the two estimation methods. This is not in line with the expectation that the value of total exports would have a positive effect on the euro invoicing percentage, not in line with the literature, which list country size as a key determinant of invoice currency choice (Goldberg & Tille, 2008) and a country's market power as a determinant of euro invoicing (Kamps, 2006). The share of US exports has a small, negative and insignificant effect in both estimation methods, although the effect is much larger in the Prais-Winsten estimation. The sign is conforming to the expectation that trade with the US diminishes the use of the euro in invoicing exports, as Goldberg and Tille (2008) found that trade with the US tends to be invoiced more in US dollars. Being a member of the Euro Area has a significant positive effect on the percentage of extra-EU exports that is invoiced in euro. Becoming a member of the EA will on average increase the euro invoicing percentage by about 9.42 percentage points according to the fixed effects model and by about 3.56 percentage points in the Prais-Winsten estimation. Since joining the Euro Area means that the euro becomes a country's new home currency, it is not surprising that this increases the euro invoicing percentage.

Table 4.1 Regression results

Dependent variable: *euroinv*

	(1) fixed	(2) PW	(3) nointerpol
export	-2.107	5.640	-21.06*
	(8.402)	(4.458)	(7.271)
USshare	-0.0432	-0.156*	0.0281
	(0.0987)	(0.0863)	(0.187)
euroarea	9.419***	3.557***	11.42**
	(1.913)	(0.235)	(2.182)
exratevol	-116.2**	-32.22	-131.6**
	(35.67)	(28.08)	(30.39)
inflationdif	-1.224**	-0.250	-1.371*
	(0.366)	(0.211)	(0.487)
manufshare	0.294***	0.266***	0.420**
	(0.0719)	(0.0777)	(0.0971)
year=2011	-0.528***		
	(0.0912)		
year=2012	-1.062***		-1.016***
	(0.107)		(0.158)
year=2013	-1.392***		
	(0.0838)		
year=2014	-2.276***		-2.661***
	(0.434)		(0.423)
year=2015	-3.075***		
	(0.772)		
year=2016	-3.663***		-4.652**
	(0.843)		(0.918)
Constant	26.59***	29.39***	21.61**
	(6.663)	(7.713)	(5.709)
Observations	189	189	108
R^2	.304	0.352	.400
Adjusted R^2	.252	0.330	.316

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(1) fixed effects model with Driscoll-Kraay standard errors

(2) Prais-Winsten estimation with robust standard errors

(3) fixed effects model with Driscoll-Kraay standard errors, with interpolated values omitted

The effect of the exchange rate volatility is negative and significant in the fixed effects model. An increase of 0.01 percentage points in the exchange rate volatility (the maximum value of *exratevol* in the dataset is 0.038) of a non-EA country vis-à-vis the euro will on average decrease the euro invoicing percentage by about 1.16 percentage points. This is not in line with the expectations and contrary to the results of Kamps (2006), who found the exchange rate volatility to have a positive effect on the euro invoicing percentage. In the Prais-Winsten estimation, the coefficient of the exchange rate volatility is also negative, but insignificant.

The effect of the inflation differential on the euro invoicing percentage is negative and significant in the fixed effects model. In the Prais-Winsten estimation, the coefficient is insignificant. According to the fixed effects model, an increase of one percentage point in the inflation differential of a country relative to the EA leads on average to a decrease of the euro invoicing percentage by about 1.22 percentage points. This is contrary to the expectation that in non-EA countries, less monetary stability (and thus a higher inflation differential) leads to more exports invoiced in euro. It is however in line with the findings of Kamps (2006), who also found the effect of the inflation differential on euro invoicing to be negative. Her explanation for this effect is that the euro is not used as vehicle currency – when countries have low monetary stability, they choose the US dollar rather than the euro as vehicle currency. Ligthart and Werner (2012) also found that a decrease in inflation volatility leads to more euro invoicing.

The results show a strong link between the share of manufactured goods in total extra-EU exports and the euro invoicing percentage. The coefficient is positive and significant in both models. An increase of one percentage point in the share of manufactured exports increases the euro invoicing percentage on average by about 0.29 percentage points in the fixed effects model and by about 0.27 percentage points in the Prais-Winsten estimation. This is conforming to the expectation for this variable. It is also in line with the literature, as it confirms Grassman's law (Grassman, 1973) and corresponds with the finding of Goldberg and Tille (2008) that homogeneous goods (i.e. non-manufactured goods) are more likely to be invoiced in US dollars.

In the fixed effects model, the year-dummies are negative and significant for each year. The year 2010 is omitted to avoid collinearity.

The third column of Table 4.1 show the results of a fixed effects model without the interpolated values. For most variables, the results are comparable to the original fixed effects model. Only the coefficient of *USshare* has the opposite sign. The size of the coefficients is

however different. The effect of a country's market power (*export*) is considerably larger (but still insignificant at the 5% level), but why this is the case is unclear. The effects of *euroarea*, *exratevol*, *inflationdif* and *manufshare* are also larger. *Inflationdif* is not significant at the 5% level, however.

In the next section, I will only consider the models including the interpolated values (i.e. the first two columns of Table 4.1).

V. CONCLUSION AND DISCUSSION

In this research, I empirically analysed the determinants of euro invoicing in extra-EU exports. Due to data limitations, not many empirical papers have been written on this subject. This study uses new data on the use of the euro as invoicing currency and tries to explain the differences in the use of the euro as invoicing currency between EU countries. In that way, this paper contributes to the existing literature. I use a balanced dataset for 27 EU countries and try to explain the percentage of extra-EU exports that is invoiced in euro using various macroeconomic variables. I use a fixed effects model with Driscoll-Kraay standard errors and a Prais-Winsten estimation to estimate the determinants of euro invoicing.

The first finding is that becoming a member of the Euro Area has a large and significant effect on the use of the euro in invoicing of extra-EU exports. On this basis, the first hypothesis, *being a member of the Euro Area significantly increases the share of extra-EU exports invoiced in euro,* cannot be rejected. Furthermore, the share of a country's exports with the United States does have a negative effect on the euro invoicing percentage but was insignificant in both models. The second hypothesis, *The share of a country's exports with the United States negatively influences the percentage of extra-EU exports invoiced in euro,* can therefore not be rejected.

The third hypothesis states that *the exchange rate volatility of a currency vis-à-vis the euro has a positive effect on the share of extra-EU exports invoiced in euro*. The effect of exchange rate volatility was negative in both models. The third hypothesis is therefore rejected. Closely related to this hypothesis is the effect of a country's inflation differential. This does also have a significant negative effect on the euro invoicing percentage, which is contrary to the expectations. This may indicate that countries with weak financial markets use another currency than the euro (probably the US dollar) as vehicle currency. The results also implicate

that the more monetary stable a non-EA country is relative to the Euro Area, the more it uses the euro as invoicing currency in extra-EU exports.

The share of manufactured goods in total extra-EU exports have a significant positive effect on the euro invoicing percentage, and hence the fourth hypothesis, *exporting relatively more manufactured goods increases the share of extra-EU exports invoiced in euro*, cannot be rejected. This is conforming to the expectation that manufactured goods are less often invoiced in US dollars.

I will now turn to answering the main question, *what are the main reasons for the differences between EU countries in their percentage of extra-EU exports that is invoiced in euro in the period 2010-2016?*

Based on the empirical analysis in this paper, it can be concluded that there exists a positive relationship between membership of the Euro Area and the percentage of euro invoicing in extra-EU exports. This is in line with the expectations and literature on this subject. Moreover, the exchange rate volatility and the inflation differential have a negative impact on the euro invoicing percentage, meaning that countries that are less monetary stable invoice less in euro. This may be an indication that the euro is not being used as a vehicle currency and confirms the literature on this subject. Finally, the share of manufactured goods in a country's total extra-EU exports positively influence the percentage of extra-EU exports that are invoiced in euro. This is in line with the existing literature, which states that more differentiated products are more likely to be invoiced in the producer's currency.

The effects on the euro invoicing percentage of exporting more to the US and of exchange rate volatility are negative, as would be expected, but the effects are insignificant. The market power of a country, which is measured by the value of a country's extra-EU exports relative to world exports, surprisingly has a negative effect on euro invoicing, but is also insignificant.

These results imply that for non-EA countries, their business cycle should be synchronized less with that of the Euro Area if they have relatively few exports of manufactured goods or high inflation differentials or exchange rate volatility with the Euro Area. This assumption could be researched in future papers. Policy makers from non-EA countries can also take the results into account when estimating the transmission of monetary policy from the Euro Area.

When interpreting the abovementioned conclusions, the limitations of this paper should be kept in mind. The data on invoicing I used are only available from 2010, meaning that I have only seven datapoints per country. With more datapoints, the analysis would become more thorough. Moreover, all the invoicing data are aggregates. Bilateral invoicing data is not available, which makes incorporating the characteristics of the importing country impossible. Furthermore, again due to data limitations, I have not been able to include industry features in my research. Goldberg and Tille (2005) have, amongst other authors, named this as an important determinant for the choice of invoicing currency.

Considering these limitations, further research could try to incorporate industry features in their analysis of invoicing currencies. Another suggestion is to conduct research similar to this one at a later point in time, when more invoicing data will be available. Future papers could also focus on the full distribution of invoicing currencies for each country, in order to make a distinction between PCP, LCP and VCP.

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APPENDIX

1. List of EU countries included in the sample

Austria	Belgium	Bulgaria	Cyprus
Czech Republic	Denmark	Estonia	Finland
France	Germany	Greece	Hungary
Ireland	Italy	Latvia	Lithuania
Luxembourg	Malta	Netherlands	Poland
Portugal	Romania	Slovakia	Slovenia
Spain	Sweden	United Kingdom	

2. Table with euro invoicing percentage per country

COUNTRY/TIME	2016	2015	2014	2013	2012	2011	2010
Austria	70.4	71.7	72.9	73.7	74.5	74.7	74.9
Belgium	45.1	45.0	44.8	45.5	46.1	48.0	49.9
Bulgaria	56.7	55.4	54	53.5	52.9	54.5	56
Cyprus	51.7	59.0	66.2	59.9	53.5	57.9	62.3
Czechia	48.9	49.1	49.2	49.5	49.7	50.0	50.2
Denmark	23.9	25.3	26.6	26.3	26	26.5	26.9
Estonia	66.3	69.2	72.1	69.2	66.3	64.2	62
Finland	53.6	59.7	65.8	60.4	54.9	52.3	49.7
France	51.1	51.7	52.3	52.7	53	53.0	53
Germany	58.5	59.9	61.2	63.0	64.7	65.6	66.4
Greece	70.6	69.7	68.7	68.8	68.8	69.5	70.2
Hungary	52.5	52.2	51.9	48.5	45.1	45.9	46.6
Ireland	6.2	8.8	11.4	10.3	9.1	9.3	9.5
Italy	72.3	74.0	75.7	75.8	75.9	76.3	76.6
Latvia	71.8	71.4	70.9	70.9	70.9	71.3	71.6
Lithuania	78.2	72.4	66.6	62.7	58.7	57.6	56.5
Luxembourg	52.2	55.3	58.3	67.2	76.1	72.9	69.6
Malta	21.9	22.8	23.7	25.5	27.3	24.8	22.3
Netherlands	59.8	56.2	52.6	52.1	51.6	53.7	55.7
Poland	57.1	58.4	59.6	60.3	61	60.0	59
Portugal	67.9	69.3	70.6	71.6	72.5	73.4	74.3
Romania	65.7	64.9	64	64.2	64.4	64.0	63.5
Slovakia	80.8	81.7	82.6	85.3	88	84.5	81
Slovenia	79.7	78.9	78.1	80.2	82.3	83.8	85.2
Spain	70.8	71.4	71.9	71.7	71.4	73.1	74.8
Sweden	17	19.5	22	23.4	24.8	23.8	22.8
United Kingdom	3.6	3.9	4.1	4.1	4.1	4.1	4.1

3. Detailed description of the data

The value of Malta's exports to the US for 2016 had an extreme value which was five times higher than the average value of the preceding years. I believe that this value is either a mistake or an event that will not be studied in this paper. For this reason, the value was replaced by the average export value of the preceding five years.

The data on the percentage of exports that is going to the US was derived from value of US imports from each EU country. This data was obtained from the US Census Bureau and based on the Customs Value.

The EA consists of all EU member states that have adopted the euro as their currency, which are Austria, Belgium, Cyprus, Estonia (in 2011), Finland, France, Germany, Greece, Ireland, Italy, Latvia (in 2014), Lithuania (in 2015), Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia and Spain. The non-EA countries included in this research are Bulgaria, Czechia, Denmark, Hungary, Poland, Romania, Sweden and the United Kingdom.

Countries in the sample which have pegged their currency to the euro are Bulgaria, Estonia (before 2011), Latvia (before 2014), and Lithuania (before 2015).

Determining an adequate measure of exchange rate volatility can be problematic (McKenzie & Brooks, 1997). I have chosen the method that is most used in recent papers, which is the Moving Standard Deviation (MSD) (Bahmani-Oskooee & Hegerty, 2007). This has the advantage of being stationary. The formula for the MSD is the following: [1]

$$MSD = \sqrt{\left[\frac{1}{n}\sum_{i=1}^{n}(x_{t+i-1} - x_{t+i-2})^2\right]}.$$

where *n* is the number of periods, *x* is the percentage change of the exchange rate, and *i* indicates the period. The monthly exchange rate for each currency vis-à-vis the euro is used to compute the monthly percentage change *x*. This is then used to compute the monthly rate of change. The rate of change is squared and summed for 12 months (n=4) and then divided by 12. Finally, the square root is taken to arrive at the twelve-month Moving Standard Deviation. I have calculated the MSD for each non-EA country for each year (2010-2016).

Some countries have not pegged their currency to the euro but do conduct a fixed exchange rate policy (e.g. Denmark). This results in very low exchange rate volatility.

4. Tables for robustness and goodness-of-fit

Table A.1 Hausman test

	Coefficients (b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
export_tot	-2.323196	-2.849509	.5263132	9.843563
USshare_tot	-.2648671	-.3406759	.0758088	.027804
euroarea	7.441183	8.139941	-.6987586	.1711546
exratevol	-85.97602	-122.1371	36.16109	5.605488
inflationdif	-.9889891	-1.030447	.0414575	.
manufshare	.2298773	.2572249	-.0273476	.0229888

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 53.07
Prob>chi2 = 0.0000
(V_b-V_B is not positive definite)

Table A.2 Modified Wald test for heteroskedasticity in fixed effect model

```
Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (27)  =   40021.70
Prob>chi2 =      0.0000
```

Table A.3 Wooldridge test for autocorrelation

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      26) =    515.613
           Prob > F =      0.0000
```

Table A.4a Test for time effects in the fixed effects model

```
. testparm i.year // TEST FOR TIME FIXED EFFECTS (NULL: NO TIME EFFECTS)

 ( 1)  2011.year = 0
 ( 2)  2012.year = 0
 ( 3)  2013.year = 0
 ( 4)  2014.year = 0
 ( 5)  2015.year = 0
 ( 6)  2016.year = 0

       F(  6,     6) = 2.8e+05
            Prob > F =    0.0000
```

Table A.4b Test for time effects in the Prais-Winsten estimation

```
. testparm i.year // TEST FOR TIME FIXED EFFECTS (NULL: NO TIME EFFECTS)

 ( 1)  2011.year = 0
 ( 2)  2012.year = 0
 ( 3)  2013.year = 0
 ( 4)  2014.year = 0
 ( 5)  2015.year = 0
 ( 6)  2016.year = 0

       F(  6,   150) =    0.60
            Prob > F =    0.7262
```