The arms trade and the euro changeover in 2002

by

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Abstract

This paper examines the relationship between the adoption of the euro currency notes in 2002 and its effect on the arms trade market. Using data from the Norwegian Initiative on Small Arms Transfers (NISAT) for 54 countries, this research uses an ordinary least square regression method to measure this relationship. We also create an import index to measure the degree of proximity of the 54 countries with the 12 euro-currency countries. Results show that undeniably, countries with more ties to euro currency countries saw their arms trade increase before the introduction of the euro.

1. Introduction

In January 2002, twelve countries adopted euro notes and coins as their sole currency (Germany, Nederland, Ireland, France, Austria, Belgium, Finland, Greece, Italy, Luxembourg, Portugal, and Spain) (Stenkula 2004). Therefore, 300 million people started using the euro currency at the same time, an event unseen in monetary history. The speed of transition to exchange a country's currency for euro was different for each country. While most former national banknotes have been exchanged for euro banknotes, some former national currencies remain unexchanged (The New York Time 2012)

The unexchanged currency could be due to collectors, could be lost or destroyed money, as well as traded in the black market. For instance, by 2012 there was still €550 million worth of franc notes unexchanged in France (The New York Time 2012). Similarly, during the same period, €6.75 billion worth of marks remain unexchanged in Germany (The Week 2012).

Criminal groups around the world are believed to hold large stocks of paper currency. Yet, people holding money obtained illegally had to find ways to exchange their cash for another currency or buy assets, all without raising the suspicions of the authorities. However, since criminal organizations often hold a large quantity of cash, it might not have been so simple for them to efficiently convert their money into another currency in a short period of time. Thus, they were left with the only option of buying assets. Furthermore, in order to be used to store monetary value, those goods needed to be non-perishable. Which raises the question of what goods would criminal groups have bought?

We believe the establishment of the monetary union in 2002 affected numerous illicit organizations worldwide. Our working hypothesis is that these groups must have decided to convert their cash into small arms or light weapons. This hypothesis is plausible as the European Union is one of the primary exporters of small arms by value, thus making it easy for criminal groups to convert large amounts of paper money to small arms in a short period of time.

In this paper, small arms will refer to the ones that can be carried by one person or can be put in a vehicle (United Nation 1997). For instance, small arms range from pistols and light machine guns to rocket-propelled grenades. Even if arms trade is a worldwide business, it is mostly seen in regions with armed conflicts, violence, and organized crime. Consequently, small arms may have been the ideal way for people to use large quantities of former currencies without having to exchange it at a bank. According to the Economist (2014), 80% of money laundering would be completed through either the arms market, drug trade, terrorism or some sort of corruption. Thus, here we are trying to uncover the potential link of arms trade with the euro changeover.

We will test whether the introduction of the euro currency in 2002 altered the arms trade market for countries that have strong links with the twelve Euro-countries. Almost 16 years after this major event, a lot of research has been done on the euro changeover and its impacts on the economy. First, studies have shown that the euro has helped reduce inflation among the European Union. Second, it has also helped lower the interest rates since the exchange-rate risk was reduced with the introduction of the euro currency. Third, the adoption of the same currency permitted a more integrated financial market (Dumitrache 2013). Past studies on money laundering have shown that there has been an "increased number of incidents in which criminal organizations involved in drug trafficking accept or demand firearms as payment in kind for illegally distributed drugs" (CND 2008). However, the introduction of the euro in 2002 and its effect on the arms trade market was never studied before. And yet, arms trade across the world has piqued the curiosity of many academics. Much research has been done relating to arms trade such as the evolution of the arms trade market, detecting illegal arms trade, the concentration in the arms trade market and much more. But again, no scholar has attempted to model the arms trade market with the introduction of the euro currency in 2002, which was an unseen event in monetary history.

To determine if there is a relationship between the introduction of the euro currency in 2002 and the arms trade activity of countries with close ties to the euro. This study will be done using the ordinarily least squares (OLS) for all the models. The reasons for choosing the models will be explained in the fourth section of this paper, where we will also perform multicollinearity checks and describe possible statistical issues.

Our results are consistent with our hypothesis. Indeed, we find a negative statistically significant relationship between the introduction of the euro and the arms trade ratio of countries with close ties to the Euro. We find that countries with close ties to the twelve countries using the

euro currency in 2002 had a smaller ratio of arms trade after the currency change to arms trade before the change. This implies that, on average, countries with strong ties to the twelve Euro-countries bought more arms before the currency change than countries with weak ties.

A secondary result concerns the relationship between the arms trade ratio and the population growth of 1988-2008. We find that past population growth (1988-1998) is a better predictor of arms trade ratio than the period of interest (1998-2008) population growth. Our plan was to estimate the population growth for 10-20 years of ages, (growth from 1988-1998) instead of the population growth for 0-10 years of ages (growth from 1998-2008) since we rarely see children younger than 10 years old using arms. A complete list of results will be given in a detailed discussion of the results in Section 6.

The paper is organized as follows. The first section will cover a literature review. Then, a brief history of the euro changeover process will be given as well as a description of the economics of arms trades. Next, the methodology will be presented followed by a data description with summary statistics. Finally, the relationship between the euro changeover and arms trade market will be tested and the results will be analyzed.

2. What do we Know About the Arms Trade Industry?

In the past, most of the focus on Arms Trade Treaty (ATT) has been on weapons of mass destruction (WMD) such as tanks, artillery, and more. However, small arms and light weapons are a much more prevalent cause of death globally as they accounted for more than ½ million lost lives per year between 2004-2012 (The Geneva Declaration 2015). Meyer (2014) studies past UN action on conventional arms, control of arms transfers, with a focus on small arms and light weapons. In

1991, the UN formed the Register of Conventional Arms. This list was established to provide some transparency over arms transfer around the world. Yet, only seven groups of weapons had to be incorporated into this new registry, which excluded small arms and light weapons. The statistics from the SIPRI website are worth noting. For instance, the increase in conventional arms trade rose by 17 % between 2008-2012 compared to the previous 4 years (2003-2007). There was most certainly a need to develop a new arms treaty. Consequently, the ATT was approved at the beginning of 2013, and its most important aspect was the addition of small arms and light weapons to the treaty. Furthermore, Meyer (2014) argues the ATT will help generate a more reliable source of data, especially for small arms and light weapon transfers around the world.

Dunne and Smith (2016) and Fieleke (1991) study the arms industry. In their 2016 research, Dunne and Smith's main objective is to analyze the variation of concentration in the world arms trade over the period 1990-2013, followed by the size repartition of arms firms. While Fieleke two main questions concentrate on explaining the economic side of arms trade using a descriptive study. First, Fieleke investigates if there is a correlation among the size of the military industry in a country and its military exports and import. Second, he studies the intra-trade industry for the arms market.

Dunne and Smith's research uses SIPRI's data which lists the top 100 weapons making companies. Potential bias was the definition of market boundaries. Additionally, the SIPRI's database did not include figures on Chinese firms and data for other countries were sometimes incomplete. To calculate the degree of market concentration of each firm, the Herfindahl-Hirschman Index (HHI) was used. They also graph the log-rank with the log of arms sales to

measure the variation in the size division of firms. Their graphs illustrate the change in rank from an increase in sales.

In 1989, a minimum of 120 countries was trading arms. All countries were importing arms, while only 47 were also exporting arms. In addition, 93 of them were considered as developing countries and they were responsible for 75% of the value in arms imports (ACDA). Dunne and Smith (2016) conclude that major variations took place in the international arms industry during 1990-2013. However, they continue to think that the evolution of this industry is being shaped by politics. They also found that the global arms trade is quite dispersed in comparison to other markets. In fact, for the year 1990-2001, the HHI index increased from 0.02 to 0.05, while in 2011 it was 0.035. According to the US Department of Justice, an HHI of 0.15-0.25 is considered as reasonably concentrated and an HHI above 0.25 is defined as very concentrated. Thus, even though the HHI index more than doubles during a period of 10 years, the arms trade industry is still considered as not concentrated. As for the log-rank vs log arms sales graph, they showed that sales increase for high-ranked companies. Dunne and Smith (2016) state that the US is still the leader in the arms market, however, they believe there are other majors differences amongst the US and Europe which would require additional research.

Fieleke uses a graph to study the relationship between military spending and arms exports as well as military spending and arms imports. The author wants to test whether economies of scale in arms markets provide a motivation to export arms in countries with small military expenditures. Specifically, if the ratio of military exports over military spending is larger for countries with small military industries. Fieleke's first graph looks like there is no overall decrease in the ratio of exports over expenditures as military spending increases. When he excluded the Soviet Union and the

United States from the data, arms exports did tend to grow with military expenditures. However, for arms imports, he concluded that it was uncorrelated with military expenditures. He reached the same finding when excluding the two outliers (the Soviet Union and the United States). Lastly, the intra-trade market for arms in the Soviet Union and the United States is an important feature of the industry. But he found that imports and exports are not related to the other countries in his research. Indeed, his analysis showed that 78 out of 142 countries were only ordering arms.

Fieleke (2010) contributed greatly to the literature of the arms trade industry by uncovering a relationship between military expenditures and arms exports. However, his conclusions are based on a descriptive study in contrast to a more in-depth analysis. For instance, he should have performed regression analysis as well as some robustness check to see if this relationship was indeed validated.

Powell (2004) wrote a literature review paper on the impact of arms trade on sustainable development. The objectives of her study were to identify gaps in previous research as well as to see whether the impact of arms trade on development is similar to different studies. Her literature review covers more than 80 sources examining the relationship between arms trade and development. Powell's study explores different relationships, but the most important ones are the impact of military spending on development, the impact of arms trade on development, and the development impact of the use, availability, and proliferation of arms. The later focusses on the effect of small arms and light weapons and its influence on social improvement. Since arms trade data are hard to obtain, the research is based on a selective survey of literature analyzing the impact of military spending on development.

In her review, Powell (2004) found that there were three main specifications used to analyze the impact of military expenditures on development; a simple regression with economic growth, represented by Gross Domestic Product (GDP) per capita as the dependent variable, multiple regression with military expenditures, economic growth, and more, as well as macro-regression models. The results of the literature review indicate that even though it seems that military expenditures can have a negative effect on social improvement, findings are usually indecisive and unpredictable. Thus, some scholars argue that if we reduce military expenditures, the savings can be reallocated to more productive purposes. Others believe that military expenditures and social improvement are not directly related.

The review on the effect of arms transfer on social improvement shows more unified results. Most scholars argue that the arms transfer market restrains socio-economic progress since countries with a low GDP per capita will reduce government spending on health and education to buy more arms. Lastly, according to Powell (2004), studies that have focused on the influence of small arms and light weapons have on development identify a few common indicators. For instance, here are some fundamental indicators used to measure the effects of small arms availability and use on development: deaths and injuries caused by a gun, armed offence, health and education, transfer and production, investment, saving and more (Muggah and Batchelor 2002). All in all, Powell's literature review of the use and accessibility of arms reveal unequivocal consequences on human development. Powell's study also emphasized that there are disagreements on results and that the methodology used in some research is poor. Also, there are some debates about selecting the right development indicators to truly find the link between arms trade and human development. Future studies should emphasis on identifying a causal relationship among different development indicators, instead of measuring social improvement solely based on economic well-being.

The growing public concern on the tendency of democratic nations to sell weapons to autocracies led Akerman and Seim (2014) to study the link between Polity-scores and arms trade and Della Vigna and La Ferrara (2010) suggested a model to find whether illegal arms trade was present. More precisely, Akerman and Seim (2014) estimate gravity models of the probability of bilateral trade and study the change over the period between 1950-2007. While Della Vigna and La Ferrara's paper is about countries under arms restrictions and specific events that change the conflict intensity in different countries. The authors believe that when illegal arms trade occurs, any event affecting the number of arms demanded by a given arms' firm will also modify its stocks price.

Akerman and Seim arms transfer measure is the sum of joint imports-exports over 1950-2007. Rebellious organizations are considered outliers and thus deleted from the dataset. Additional data was collected such as GDP per capita, distance between countries, official language, shared borders and past colonization. Lastly, the authors took the aggregate arms transfer from the UN Comtrade database for the years 1962-2000. In order to determine if there is a relationship between democracy levels and arms trade, Akerman and Seim graph the Polity-scores of exports destination for six majors arms trade exporters from 1950-2007. Next, they estimated a gravity model of arms trade. The results indicate that the distance in Polity-score is negatively correlated to the likelihood of arms transfer. In fact, the most democratic country is 60% more unlikely to engage in arms transfer with the most autocratic country than with a country that has a similar Polity-score. The rest of their paper investigate if this relationship is stable throughout the years. One major drawback from Akerman and Seim (2014) gravity models is that they limit their observations to countries with trade flows with one another greater than 0, thus eliminating countries with no trade between them. Furthermore, Akerman and Seim (2014) discovered that the

likelihood that two nations participate in arms trade increases if they were in a colonial relationship in the past. However, their study does not explore other aspects of this relationship.

Della Vigna and La Ferrara's study takes an event study approach to see if conflict events change stock prices for weapons-making firms. They plot abnormal firms returns during embargo and without embargo, followed by some regressions using the proposed indices. Increase in conflict during ban tends to decrease stock price considerably by 0.42% for not highly corrupted countries. The effect of such event when the country is highly corrupted increase by 1.15%. The main results of Della Vigna and La Ferrara's paper were that unusual event returns are due to both legal and illegal arms sales, as well as firms in very corrupted countries have higher probabilities of violating arms restriction.

Still, some statistical issues with the model are important to mention. Della Vigna and La Ferrara state that their results report the mean effect for firms, not a generalization that all firms are trading illegally. In addition, one assumption of their study is that investors are well-informed. If this assumption is invalidated - for instance, the investor is misinformed - it is quite possible to conclude that firms were trading illegally when it was not the case. Lastly, the results do not infer that the arms ban are not being respected. One explanation would be that arms trade goes through another country first.

According to Dunne and Smith (2016), politics are shaping the arms trade market as opposed to economics. What if the change in export demand for small arms and light weapons in Europe was linked to an economic factor such as the Euro currency changeover? In the first decade of 2000, the European Union was the second largest exporter of arms worldwide, after the United States

(SIPRI 2015). This led us to investigate what might have been affecting the trend in arms export in the EU between the end of the cold war and the first decade of the 21st Century. Nevertheless, no past research has attempted to answer this question. In DellaVigna and La Ferrara's (2010) research, the main question they are trying to answer is which nations are involved in criminal arms export to areas of civil conflict. Though, their paper is only concerned about uncovering countries exporting arms to areas of civil conflict as opposed to why in some years arms exports have increased. In this paper, we propose a hypothesis to explain why there was an increase in arms export from European Countries in late 1990 and the beginning of 2000.

The above six papers are part of the most significant research about the arms market that was found. As we saw, Meyer (2014) discusses the new Arms Trade Treaty which now includes small arms and light weapons, Dunne and Smith (2016) examined the variation of concentration in the world arms trade over 1990-2013, Fieleke (1991) explored the relationship among the size of the military industry in a country and its military exports and import, and the intra-trade industry, Powell (2004) performs a literature review to summaries the finding on the impact of arms trade on development, Akerman and L. Seim (2014) studied whether there is a relationship between Polity-score and arms trade, Della Vigna and La Ferrara (2010) advocated an equation to uncover illegal arms trade. There were two major sources of data for these papers: the SIPRI and the Polity-scores. Fieleke (1991) explains that the arms industry is affected by countless variables such as altruistic concern as well as greed. These variables are very hard to measure, therefore making it almost impossible to estimate their true impacts on arms trade. In this situation, Fieleke states that it is better to use a regression model with fewer variables. From this literature review, we can notice that a lot of different studies that have been devoted to the arms trade industry.

Small arms trade and light weapons are thought to be traded legitimately most of the time; only 20% of arms trade would consist of illicit exchange (IBP 2018). In addition, 650 of the 875 million small weapons were in civilian hands in 2007, while 857 of the 1 billion are now in civilian hands (The Guardian 2018). Small arms and light weapons are a growing area of concern and many countries are trying to put an end to its proliferation. However, the first step in disarmament would be to identify the connexion between legal and illegal weapons ownership. More specifically, the now illegal small arms were previously legal arms. Thus, it is primordial that we understand what would make an organization or groups of people import more and more small arms and light weapons to their country to resale them on the black market? For instance, these groups are trying to exchange large amounts of former currency without going to a bank.

The Euro currency changeover has created a lot of debates on whether it changed the well-being of its citizen. For instance, Wunder et al. (2008) perform a parametric difference-in-difference analysis to evaluate the effects of the Euro currency change over on the well-being of European. Their study demonstrates that there were no real effects on the welfare of its citizen, even though most individuals overestimated inflation. Still, no research has been devoted to the impact of such major currency changeover on other nations. For instance, it would be interesting to see if the currency change over has raised arms trade proliferation in developing countries. This question is noteworthy since small arms and light weapons are the main cause of poverty and death in emerging nations (Small Arms Survey 2005) and we are still hesitant has to the reason why armed group imported such large quantities of arms in late 1990 and the beginning of 2000. No empirical research has been done on the relationship between the arms market and the euro changeover until now. More specifically, we will explore the possible effect that the adoption of the euro currency notes in 2002 had on the arms trade market if any.

3. A Brief History of Euro Changeover

The vision of establishing a common currency for multiple nations dates well before the formation of the European Union. For instance, the Latin Monetary Union (LMU) was adopted in 1865; it regrouped multiple currencies from European countries into a unified currency (Kee-Hong and Bailey 2011). At the time, most countries were still using gold and silver to make their coins. This Union lasted until late 1927. The 3 main reasons of the fall of the LMU was that each country manufactured their own coins, the sharp decrease in the value of silver itself, as well as the final shock World War I (Kee-Hong and Bailey, 2011).

World War I triggered the establishment of new nations in Europe, from which rose economic separation. Consequently, in 1929 Gustav Stresemann brought the idea of creating a European currency in order to unify these countries again (EUR-Lex, 2011). It was only 40 years later (1969) that an effort to establish a common currency among European communities started (EUR-Lex, 2011). The proposal was to adopt the common monetary system in late 1970. However, the plan encountered major interruptions due to the unexchangeable US dollar crises (EUR-Lex 2011). More specifically, the US dollar had a fix exchange rate with gold, but people believed the US dollar was worth less than this conversion rate. Thus, in 1971, U.S. President Richard Nixon had no other choice but to interrupt the US dollar conversion with gold (International Monetary Fund, 2018). This event is known as the Bretton Woods System failure. Another setback that was preventing the establishment of the monetary union was the increase in oil prices in the early 1970s (International Monetary Fund, 2018).

Many years passed after the failure to establish the monetary union until the idea was reintroduced in 1988. At this time, a clear agenda was proposed with important deadlines and

realistic steps. The euro changeover would take place from 1990 to 2002 and would be divided into three major stages. During the first step, which lasted three years, capital control was abolished along with an increase in collaboration and union of the twelve-member countries (Stenkula, 2004). The second stage (1994-1998) was the European Monetary Institute (EMI) establishment and monetary cooperation reinforcement. The last step (1999-2002) was the exchange rate determination which would be irreversibly fixed and the actual introduction of the euro as the new currency. The European Union established common procedures to be followed by every country during the currency transition. However, there were also specific national strategies. For instance, the quantity of pre-distribution of euro notes, as well as the time-lapse of the dual circulation (Stenkula, 2004).

One major advantage of the monetary union for countries was to encourage trade within Europe (European Commission, 2018). This was made possible through the elimination of exchange rate volatility and increased price transparency. Similarly, between 1998 and 2006, extra-euro trade has increased from 24% to 33% of GDP (European Central Bank, 2007). Another benefit that should occur after the introduction of a monetary union is an increase in labour mobility. However, this seems to be limited in most countries in the European Union (European Central Bank, 2007). In sum, the introduction of the euro currency in 2002 was made possible due to the contribution of many people over many decades. Today, we know there were a lot of benefits resulting from this cooperation. However, as we pointed out earlier, we are still not sure if the introduction of the euro had repercussion on the arms trade markets and more so on countries with close ties to the first 12 countries using the euro. Thus, in the next section, we will explain how we will attempt to model this relationship.

4. Empirical Strategy

Our identification strategy relies on the introduction of the euro currency in 2002. We attempt to determine if the euro changeover influenced small arms trade for countries with close ties with the euro currency as opposed to countries with weak ties to it. We are assuming a log-linear relationship between the ratio of arms trade for a country and the independent variables in our model. There are five outcome variables in our model; arms trade value, imports percentage, authority score, GDP per capita, as well as the population which are all country-year observations. There are 54 countries and 10 years under analysis. The dataset is cross-sectional and has a total of 2,311 observations. We will use ordinary least square (OLS) regressions to test our different models. Our study is innovative since no other researchers have focused on finding the impact of the euro currency changeover on small arms trade.

Model 1

$$ln\,R = B_1 + B_2 I_{euro} + B_3 A\_I_{euro} + B_4 GDP_{Growth} + B_5 n\_2$$

Where we define our dependent variable *R* as the ratio of average arms trade between 2005-2008 over average arms trade between 1998-2004. While *lnR* is simply the logarithm of *R* plus 10. For instance, when *R* is equal to 1, *lnR* is equal to 0 + 10. The next variable in the equation, I_{euro}, represents the percentage of total imports in a country that comes from a country using the euro currency as of 2002. The Authority index variable means the higher the index the more autocratic the country is. The two last variables are simply the *GDP per capita growth* and the population growth (*n_2*) by country.

These four independent variables were chosen to explain arms trade for different reasons. First, we want to find out if the establishment of the euro currency in 2002 had an impact on the level of arms trade for countries with a close relationship with the twelve countries going through

the currency changeover. We believe that the percentage of imports coming from countries using the euro currency in 2002 will be a good proxy for the degree of proximity with these countries. Second, as we saw in other papers the level of authority will affect the small arms trade in a country, thus it is important to include this variable in our model. Lastly, we will be controlling for population growth and GDP per capita growth to avoid biases.

Before we describe data, we will state how we expect the independent variables to affect our dependent variable *lnR*.

Hypothesis 1: The stronger the ties (measured by the ratio of imports from the 12 Euro countries) between the arms importer countries and the euro, the higher the arms sales prior to the monetary union.

Hypothesis 2: Less democratic countries will have a higher volume of arms trade, holding everything else constant.

Hypothesis 3: Population growth will tend to increase arms imports.

Hypothesis 4: GDP per capita will have an ambiguous effect on arms trade. On one side, an increase in GDP per capita will make people better off, therefore a decrease in violence, as well as a decrease in small arms, need. On the other hand, an increase in GDP per capita will make small arms more affordable for citizens, thus increasing its demand.

Hypothesis 5: Population growth during the period 1988-1998 should have a closer relationship with arms trade than population growth from 1998-2008.

We will also estimate 4 other models that include a small change from our original model.

Model 2

$$\ln R = B_1 + B_2 I_{euro} + B_3 A\_I_{euro} + B_4 GDP_{Growth} + B_5 n\_1$$

Here the only difference is the period for which the population growth was calculated, from 1988-1998 (10 years prior to the model 1).

Lastly, we will estimate tree other models in order to perform a robustness check. The objective of this test is to see how the coefficients (as well as their sign) and the levels of significance change when we remove variables from the model. For instance, we use model 4 to check if a different measure of democracy still gives us the same data trend.

Model 3

$$\ln R = B_1 + B_2 I_{euro} + B_3 \sqrt{Corr * I_{euro}} + B_4 GDP_{Growth} + B_5 n\_1$$

Model 4

$$\ln R = B_1 + B_2 I_{euro} + B_3 A * I_{euro}$$

Model 5

$$\ln R = B_1 + B_2 GDP_{Growth} + B_3 n\_1$$

5. Data Description

5.1. Collecting data

To perform our regressions, we need to collect data on small arms trade, GDP per capita, population, imports by countries of origin and level of democracy for all the countries available.

As mentioned earlier, it is extremely hard to find an exhaustive list of all small arms transfers for a given period. The only accessible small arms trade database found was the Norwegian Initiative on Small Arms Transfers (NISAT). This site has more than 1.3 million registers of transfers between 250 countries from 1962-2015. To obtain small arms trade imports for all countries, we had to manually select each country one at a time and export the data into an excel spreadsheet. We change the "Select Level of Detail" to "Small Arms" to obtain only the data on small arms trade. Unfortunately, for some countries data was not available for parts of our analyzed period (1998-2009), thus these countries were not included in our data.

The main objective of this paper is to model the volume difference in arms trade after the euro currency changeover and before the change by country. Therefore, we created a ratio of the average of arms trade after the transition over the average of arms trade before the transition. We called this ratio *R*. As previously mentioned, the reliability of the arms trade dataset could possibly be an issue in estimating our models. Therefore, we will use small arms exports transparency barometer later to verify the reliability of our data (Small Arms Survey 2018).

Here is a list of all the countries we could obtain information on arms trade for the period 1998-2009.

TABLE 1 - Countries under analysis

Albania	Ghana	Nicaragua
Argentina	Guatemala	Niger
Belize	Guyana	Oman
Bolivia	Honduras	Panama
Brazil	Hungary	Paraguay
Burkina Faso	India	Peru
Cameroun	Indonesia	Philippines

Chile	Japan	Poland
China	Kenya	Russia
Costa Rica	Latvia	Senegal
Cote d'Ivoire	Lebanon	Slovakia
Croatia	Lithuania	Sudan
Cyprus	Madagascar	Tanzania
Czech Republic	Malaysia	Tunisia
Egypt	Mali	Uganda
El Salvador	Mauritius	Uruguay
Estonia	Mexico	Venezuela
Ethiopia	Morocco	Zambia

Our analysis also required to gather data on GDP per capita and population. All this information was easily accessible online on The World Bank website and was then imported into an excel spreadsheet (World Bank 2018). To make the arms trade sales and GDP per capita comparable, we converted the values into constant year value. We choose the constant year 2012 since our last data were for that year. We used the consumer price index to transform the arms trade and GDP per capita. For instance, to obtain the constant 2012 dollars value for arms trade during 2008, we multiplied the arms trade for 2008 by 1 plus the CPI index for 2008, 1 plus the CPI index for 2009, 1 plus the CPI index for 2010, 1 plus the CPI index for 2011. Thus, by repeating that process respectively for each year, we get all values as of 2012 dollars.

The next step was to collect data to build a level of proximity index for all the 54 countries (all the countries for which we had information on arms trade) with the twelve Euro currency countries. Therefore, we decided to use imports as a proxy to estimate the level of proximity between the 54 countries and the twelve Euro currency countries. Imports dollar value by country of origins were also daunting to find and the only website that had such information was The Observatory of Economic Complexity (OEC 2018). We added the imports values of the 12 euro-currency holders (Germany, The Netherlands, Ireland, France, Austria, Belgium, Finland, Greece,

Italy, Luxembourg, Portugal, and Spain) by country and computed the share of this sum on the total imports per year. This gave us the proximity index that we call I_{euro} in our analysis.

Lastly, we used the "polity IV" website to obtain information on the level of democracy in each country. This online platform plots annual polity scores for 167 countries from 1946 to 2013. Thus, we collected data from 1996 to 2005 and computed the average, which is the score we will use in our analysis. Polity scores are shown on the map below. We had to modify the value since they were ranging from -10 to +10 and it would not yield meaningful results when used for regression. Thus, we decided to make the index from 1 to 20, the higher the score, the less democratic a country is. To transform the index, we multiplied each authority score by -1 and added 11. For[1] instance, if a country had an authority score of -7, our new value would be 18 [1]. The figure on the next page shows the map of the authority scores by countries.

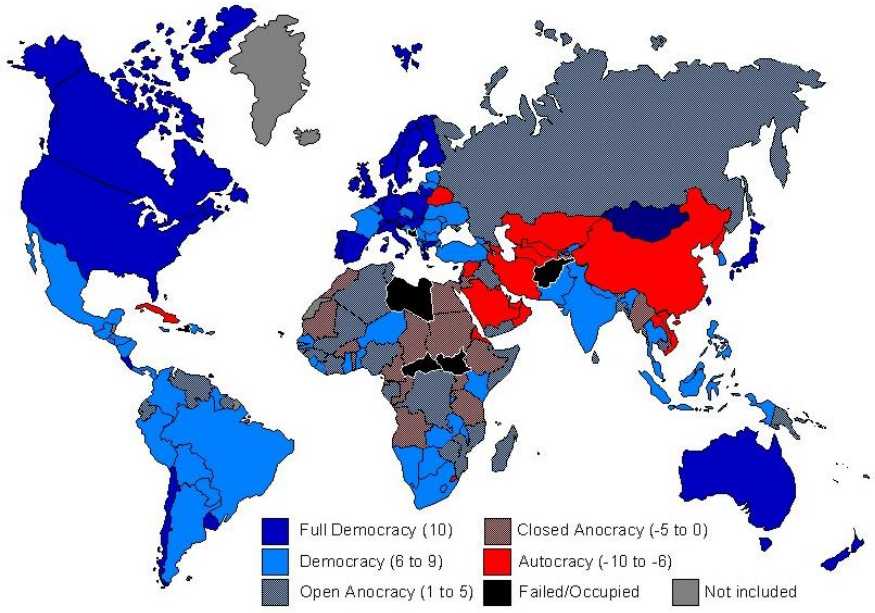

FIGURE 1 Polity Score

SOURCE: https://www.systemicpeace.org/polity/polity4.htm

[1] (-7) * (-1) + 11 = 18

It is important to note that data such as GPD per capita as well as the population by countries are very accurate measures. In addition, imports by country of origins and Polity-scores are also reliable data. On the other hand, small arms trades data are very hard to find and might not include all arms transfer that took place. There seems to be a lack of regulation for such reporting, as well as a lack of funding to provide an extensive database for all countries. Also, a country might not want to reveal total arms trade expenditures fearing for its national security. The last observation is mostly related to military spending; thus, we believe that small arms trade dataset should be close to reality. In order to mitigate the effect of missing information in our model, we took the average arms trade for several years.

5.2. Transforming our dependent and independent variables

If we try entering the variable *R* (the average arms trade after the transition over the average arms trade before the transition) as a dependent variable in a regression we will notice a problem. The issue arises because *R* is not normally distributed. To find the transformation needed to make *R* more normally distributed, we use the command "ladder" into Stata which will yield figure 2.1 of the appendix. In this special case, there is only one value for the chi-square, but usually, we have to choose the transformation with the smallest chi-square. For instance, here we will need to transform *R* into *lnR*. We repeat the same steps for all the independent variables. Our results show that I_{euro} (our proximity index with the euro) doesn't need a transformation while $A * I_{euro}$ (Authority score multiplied by I_{euro}) does. In figure 2.3 of the appendix we can see that the square root of $A * I_{euro}$ has the smallest chi-square, thus this will be our new variable. The next subsection will show histograms of the effectiveness of these changes.

5.3. Histograms

The left figure in 3.1 in the appendix is a histogram of average arms trade after the currency change over the average arms trade before this event which we called *R*. The right figure in 3.1 is a histogram of the *lnR* with a normal trend line. Thus, here we can notice that in order to have meaningful regression estimates we need to use *lnR* for which the histogram is close to a normal distribution. Not using *lnR* will make the regression harder to interpret. For instance, if *R* is between 0 and 1, this means that average arms trade was lower after the changeover than before, while an *R* greater than 1 implies that average arms trade was higher after the changeover than before. Hence, the ratios are not symmetrical.

The left figure of 3.2 in the appendix displays a histogram of the authority score times euro index of each country while the right figure of 3.2 is the square root of Authority score * I_euro. Again, here we can see that in figure 3.2 most of the scores are concentrated between 0 and 2, while figure 3.2 looks more like a normal distribution, even though it is still not perfect. Lastly, the left figure of 3.3 in the appendix presents a histogram of the corruption score of each country while the right figure of 3.3 is 1 over corruption score square. Once more, transforming the data will make the regression results easier to interpret.

5.4. Correlation

We start by plotting the correlation between our dependent variable *lnR* and the three independent variables. Figure 2.1 shows the relationship between *lnR* and I_{euro}. We can see from this graph that there seems to be a negative trend between the percentage of imports that come from euro currency countries and the value of *lnR*. There is also a linear pattern with Authority score and lnR

(figure 2.2) but this time the relationship is positive. The last graph, figure 2.3, shows no clear pattern between the countries number (from iso3n) and *lnR*, which is intuitive, there should not be a trend in the ratio of arms trade sales after and before the euro changeover and country randomly selected number.

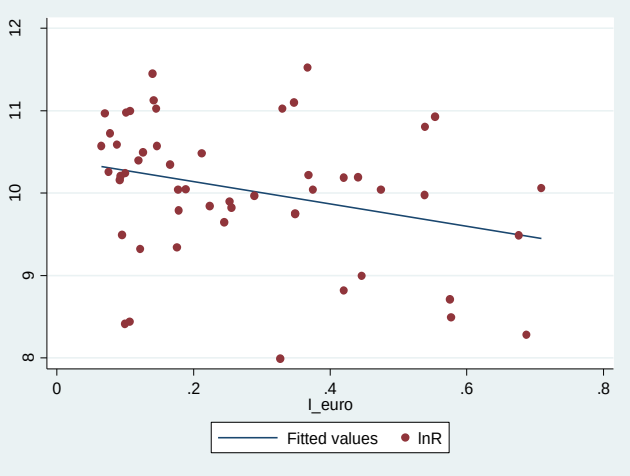

FIGURE 4.1 Scatter plot of lnR and Ieuro

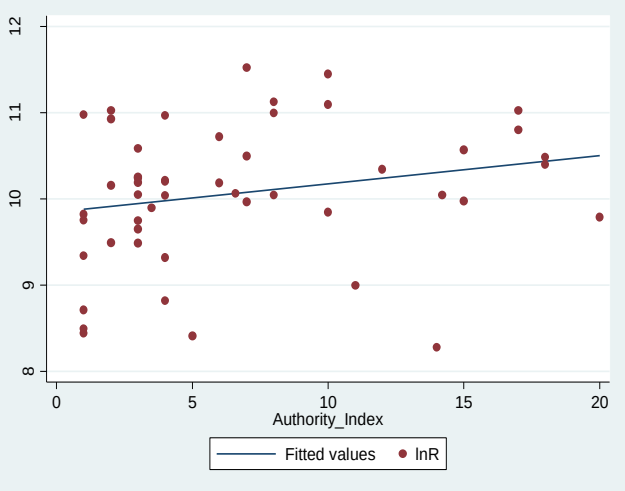

FIGURE 4.2 Scatter plot of lnR and Authority Index

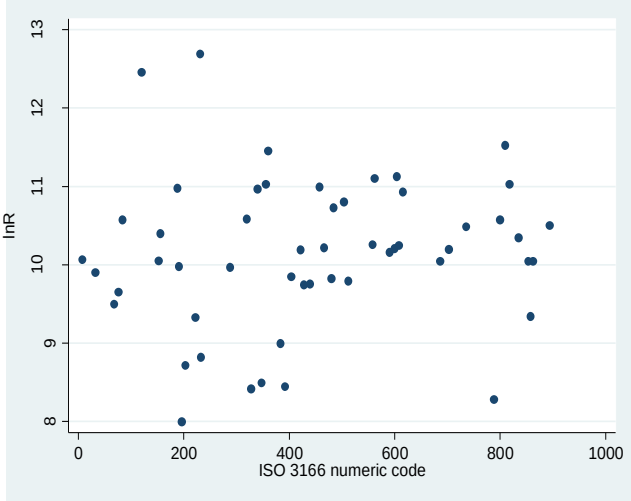

FIGURE 4.3 Scatter plot of lnR and numeric code for countries

5.5. Summary Statistics

TABLE 2 Summary statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Imports	540	0.266	0.182	0.0438	0.739
Authority_Index	530	6.870	5.472	1	20
avrg_bef	54	6.511e+06	2.037e+07	25,438	1.461e+08
avrg_aft	54	4.472e+06	6.625e+06	15,225	2.910e+07
R	54	1.829	2.456	0.135	14.72
lnR	54	10.13	0.947	7.994	12.69
I_euro	54	0.278	0.183	0.0649	0.709

The output above represents the summary statistics for the dataset. Our dependent variable *lnR* ranges from 7.99 to 12.68. There are more observations available for the average arms trade before the euro changeover process because we include more years, however, since we take the average of the observations this will not hinder our analysis. In addition, we can see that the percentage of imports that comes from one of the twelve Euro currency countries varies from about 4 % to 74%, thus our dataset contains countries that have different levels of ties with euro, which is good for our analysis. Lastly, we can see that we have the authority index for only 53 countries which is due to missing authority index information for Belize.

6. Results

Prior to estimating our equations, we need to make some specifications. Here we will be using a level of significance of 0.05, which means that there is a 5% risk of concluding that an independent variable is significantly different from 0 in our estimated model when in fact it should be 0.

6.1. Estimation of Models

TABLE 3 Results from regression models 1-4

VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3
Ieuro	-2.790***	-2.600***	3.716*
	(0.877)	(0.842)	(1.857)
A*Ieuro	0.185**	0.165**	
	(0.0811)	(0.0810)	
n_2	-0.216		
	(0.347)		
GDP_growth	0.448	0.615**	0.459*
	(0.290)	(0.294)	(0.237)
n_1		0.673***	0.497**
		(0.216)	(0.192)
Corr*Ieuro			-2.592***
			(0.820)
Constant	10.29***	10.02***	11.18***
	(0.234)	(0.226)	(0.408)
Observations	53	53	54
R-squared	0.175	0.230	0.319

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

TABLE 4 Description of the Variables

Variables of the Models	
lnR	The logarithm of the ratio of the average arms trade after 2004 (excluding 2004) and the average arms trade before 2004 (including 2004)
Ieuro	The percentage of total imports that come from the 12 countries using the euro
A	The level of authority in a country ranging from 1 to 20, the higher the score the more authocratic the country is
A*Ieuro	The authority score multiplied by the percentage of imports coming from the 12 countries using the euro
Corr	The corruption perception
Corr*Ieuro	1 over the square of (the corruption score multiplied by Ieuro)
n_1	The population growth between 1988-1998
n_2	The population growth between 1998-2008
GDP	The GDP per capita growth between 1998-2008 (using constant 2012 values)

6.1.1. Did the euro currency changeover in 2002 affect arms trade? (Model 1)

We start estimating model 1 by performing an OLS regression. The results are presented in table 3. The coefficient for I_{euro} (-2.79), the coefficient for $A * I_{euro}$ (0.185) are significantly different from 0 since their p-values are smaller than 0.05. The last two variables, population growth during 1998-2008 and GDP per capita, of our model are not significantly different from 0 since their p-value are bigger than 0.05. This suggests that the population growth during 1998-2008 as well as the GDP per capita growth do not have a significant effect on *lnR*.

The sign of the coefficient for the variable I_{euro} is negative, while the sign of the coefficient for the variable $A * I_{euro}$ is positive. Thus, for large values of authority score (note that the maximum value of authority is 20), the impact of the I_{euro} on *lnR* will be positive. This confirms our hypothesis 2 that more autocratic countries will be expected to have a higher average of arms trade after the euro changeover, holding everything else constant. For example, consider an

authority score of 20, the effect of I_{euro} will be positive[2], an authority score of 15.1 will eliminate the effect of I_{euro} in the model[3], and an authority score below 15.1 will be expected to decrease *lnR*[4].

Like we previously mentioned, the coefficient of I_{euro} is negative and statistically significant, implying that *lnR* decreases as I_{euro} increases. In other words, a unit increase in I_{euro} decreases the ratio of average arms trade after the euro changeover to the average of arms trade before it by 0.57%. This suggests that countries with strong ties with euro-countries will see their average arms trade before the euro changeover increase holding everything else constant as opposed to the countries with weak ties. We can also conclude that as imports from Euro-currency countries increase for a given country its *lnR* is expected to decrease due to the introduction of the euro. The regression results for model 1 are in line with our previous hypothesis, except for the population growth that cannot explain variation in arms trade.

6.1.2. What happens to the significance level of our variables when we modify population growth period? (Model 2)

For the second regression, we used a different measure for population growth than the previous model. Our hypothesis was that an increase in population will increase arms imports. However, when we calculate the population growth from 1998-2008 we are measuring the increase in population for the 0-10 years of age mostly. Therefore, our intuition was to calculate the population growth for 10-20 years of ages, hence, we calculated the growth from 1988-1998 (n_1) instead.

[2] (- 2.79* I_{euro} + 0.185 * 20 * I_{euro} = 0.91 * I_{euro}), thus a positive effect on *lnR*.
[3] (- 2.79* I_{euro} + 0.185 * 15.1 *I_{euro} = 0 * I_{euro} = 0), thus eliminating the effect on *lnR*.
[4] (- 2.79* I_{euro} + 0.185 * 12 *I_{euro} = - 0.57 * I_{euro}), thus a negative effect on *lnR*.

The results for this regression were similar for most coefficients but very different for the new population growth (n_1). As it was the case in the other regression, I_{euro} and $A * I_{euro}$ are still both statistically different from 0 since their p-values are lower than 0.05. The significance level of the coefficient of the population growth (using different years) greatly improved. When using the population growth from 1988-1998, the coefficient is now statistically significant since its p-value is lower than 0.05.

Here the estimated coefficient for the variable population growth (1988-1998) is positive, thus it will affect *lnR* positively. Here we have the log of a ratio, thus a unit increase in population leads to a percentage increase in the ratio R. This is in line with our hypothesis 3 and 5. Holding everything else constant, when there are more people in a country than before, the average value of arms trade will increase producing a higher *lnR*.

6.1.4. Is the authority level in a country a good variable? (Model 3)

In model 3, we decided to use a different variable to measure the level of democracy in a country. Here we change the authority index with the corruption perception. The results for the variables that were not changed are very similar to previous regression results. The variable I_{euro} is highly significant with a p-value of 0.001. Thus, we conclude that including a measure of authority is justified in our model.

6.2. Interpreting model 2

In a log-linear model, the estimated coefficients have a different interpretation than in a regular linear model. The intercept in our second model is equal to 10.02 and it can be interpreted as the log of geometric average of the arms trade ratio when all other variables are 0. Thus, in our model,

it means that when all other independent variables are set to 0, the ln of the ratio of the arms trade after the euro changeover to the arms trade before the change is approximately equal to our constant 10.02. In other words, when there are no variation in GDP, no population growth, and no imports coming from the 12 countries in the monetary union the average of the arms trade after the transition over the average of the arms trade before the transition are equal. Note that we modified our lnR observations by adding 10 unit to each observation in order to get only positive values. For example, when *R* is equal to 1, *lnR* is equal to 0 + 10. We do this to avoid having negative or undefined results since *R* can be less than 1.

Furthermore, in a log-linear regression, each unit increase in an independent variable will cause an anticipated rise in the log of arms trade ratio by *Bi* (the estimated coefficient of the independent variable that has increased by 1 unit). As for the ratio of the arms trade itself, each unit increase of an independent variable will produce an increase of e^{Bi} in the arms trade ratio. In other words, one unit increase in an independent variable increases the arms trade ratio by approximately (*Bx100)%*. We can also calculate other variation such as a 0.1 unit increase in an independent variable. For that, we simply multiply our dependent variable by $e^{0.1Bi}$.

The derivative of *lnR* with respect to I_{euro} is[5];

$$\frac{\partial lnR}{\partial Ieuro} = -2.6 + 0.165\, A_{index}$$

Hence, we see that the derivative of *lnR* according to I_{euro} is equal to - 2.6 plus 0.165 times the authority index score. When 2 countries have a 1-unit difference in imports level this is equivalent

[5] We calculate the derivative $\frac{\partial lnR}{\partial Ieuro}$ from the estimated equation of model 2:
$ln\,R = 10.02 - 2.6I_{euro} + \quad 0.165A\_I_{euro} + 0.615GDP_{Growth} + 0.675n\_1.$
Note $A\_I_{euro} = Authority\ index\ multiplied\ by\ I\_euro$

to a 100% difference in imports percentage coming from the 12 countries using the euro. Thus, a country has all its imports coming from the 12 countries using euro currency and the other countries have 0% of its imports coming them. Assuming they have the same GDP growth, the same population growth and that their authority scores are both equal to the mean authority score (6.878), we should expect their ln ratio of arms trade to differ by 1.47 unit[6]. More precisely, the country with a high percentage of its imports coming from euro currency countries will have an ln ratio of 1.47 units lower than the country with no imports. Now, if we take a smaller difference in imports level that is a 50% difference in imports. For example, country A has an import totalling 40% while country B has an import totalling 20% and keeping the same authority score as before. In this case, we expect the ratio of arms trade (lnR) to be lower by 0.29 units[7] for country A, which has a higher percentage of imports coming from countries using the euro. These results are consistent with our hypothesis 1 that countries with stronger ties with countries that are using the euro currency will have a lower ratio of arms trade holding everything else constant.

The derivative of *lnR* with respect to the authority score is[8];

$$\frac{\partial lnR}{\partial A_{index}} = 0.165\, I_{euro}$$

The derivative of lnR according to the authority score is equal to 0.165 multiplied by I_{euro}. Therefore, a 1 unit increase in the authority score between countries, keeping all other variables

[6] $From\ the\ derivative\ of\ lnR\ with\ respect\ to\ Ieuro\ we\ get$
$\Delta ln\, R = -2.6 \quad + \quad 0.165 A_{index} = -2.6 * +0.165 * 6.878 = -1.47.$

[7] Now we calculate the difference in lnR from 2 different levels of imports (holding everything else constant):
$ln\, R = -2.6\, I_{euro} + \quad 0.165 A\_I_{euro} = -2.6 * 0.4 + 0.165 * 6.878 * 0.4 = -0.58$
$ln\, R = -2.6\, I_{euro} + \quad 0.165 A\_I_{euro} = -2.6 * 0.2 + 0.165 * 6.878 * 0.2 = -0.29$
The difference between -0.58 and -0.29 is -0.29.

[8] We calculate the derivative $\frac{\partial lnR}{\partial A_{index}}$ from the estimated equation of model 2:
$ln\, R = 10.02 - 2.6 I_{euro} + \quad 0.165 A\_I_{euro} + 0.615 GDP_{Growth} + 0.675 n\_1.$
Note $A\_I_{euro} = Authority\ index\ multiplied\ by\ I\_euro.$

constant will result in an expected increase of 0.165 multiplied by import level. For example, if country A has an authority score of 8 and country B has an authority score of 9 and that both countries have 30% of their imports coming from the 12 countries using the euro currency, then *lnR* is expected to be greater by 0.05 unit[9] for country B (the country with the highest authority score). A country with higher level of autocracy is usually characterized by high-level corruption, as well as a high level of violence. Thus, this could explain why people in more autocratic countries tend to import more arms.

6.3. Multicollinearity Check

After estimating different models, we need to check the correlation between independent variables. Multicollinearity problems arise when the independent variables in a model are highly correlated together. This can cause the coefficients in a regression to be invalid because they cannot be calculated separately. Thus, we check if the independent variables in our model have a multicollinearity issue. There are few methods to check for multicollinearity. First, if we perform different regression analysis and the sign of the estimates changes from one model to the other, this is a sign of multicollinearity. As we can see from our previous regression results, signs for our coefficients do not vary between models. Second, as we can notice for the table below, correlations between pairs of independent variables are not alarming. For instance, the highest correlation between 2 variables is 0.326 for the population growth and the GDP per capita growth.

[9] $From\ the\ derivative\ of\ lnR\ with\ respect\ to\ A\ index\ we\ get$
$\Delta ln\, R = \ 0.165 * Ieuro = 0.165 * 0.3 = \ 0.05.$

TABLE 5 Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)
(1) I_euro	1.000				
(2) Authority_Index	0.126	1.000			
(3) Corruption_Index	0.147	-0.280	1.000		
(4) n_1	-0.059	0.150	-0.249	1.000	
(5) GDP_growth	0.271	0.090	0.044	-0.326	1.000

Third, we used a more sophisticated way of detecting multicollinearity, the Variance Inflation Factors. This method will measure how much the variance could be overstated. From the figure below, we can see that the VIF for I_{euro} is 1.79, $A * I_{euro}$is 1.735, *GDP per capita* is 1.215, and population growth (*n_1*) is 1.181. Menard (1995:66) specifies that "tolerance of less than 0.20 is cause for concern; a tolerance of less than 0.10 almost certainly indicates a serious collinearity problem." The maximum acceptable VIF level corresponds to the inverse of the tolerance level. Thus, a tolerance of 0.20 is equal to a VIF of 5 and a tolerance of 0.10 to a VIF of 10. While Hair et al. (1995) advocate that a Variance Inflation Factor smaller than 10 is a sign of insignificant collinearity. In our model, the highest VIF is 1.795 for the variable I_{euro} and it corresponds to a tolerance of 0.557 which is much higher than the required tolerance of at least 0.2. Therefore, these variance inflation factors reinforce our previous results, that the predictors in the model should not be highly correlated together. Thus, it is safe to assume that the estimates for our regression should not be biased because of multicollinearity.

TABLE 6 Variance inflation factors

	VIF	1/VIF
I euro	1.795	.557
A*Ieuro	1.735	.577
GDP growth	1.215	.823
n_1	1.181	.846
Mean VIF	1.481	.

6.4.Robustness Check

6.4.1. What happens when we remove variables?

TABLE 7 Results from regression models 5 and 6

VARIABLES	(1) Model 4	(2) Model 5
I_euro	-2.265***	
	(0.749)	
A*Ieuro	0.163*	
	(0.0811)	
n_1		0.758**
		(0.316)
GDP_growth		0.306
		(0.282)
Constant	10.43***	9.793***
	(0.217)	(0.225)
Observations	53	54
R-squared	0.138	0.079

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

When we remove the GDP per capita growth as well as the population growth for 1988-1998, we get an R-square of 0.1384. This implies that even without other variables, our main independent variables can explain a relatively large part of the variation of lnR. Also, both coefficients estimates are still statistically different from 0 at the 5% level. Thus, our results seem robust.

Lastly, when we remove I_{euro} and $A * I_{euro}$ we still get similar results. For instance, the variable *n_1* (population growth during 1988-1998) is still significantly different from 0 since its p-value is 0.02. Additionally, GDP per capita growth is not statistically significant, implying that it does not play a role in predicting our dependent variable. Since we obtained an R-square of almost 0.08, it would be interesting to see how much population growth can predict *lnR*.

6.5. Reliability of Arms Trade Data

We will now look at the reliability of our dependent variable; arms trade data and if this can change the sign of the relationship with our independent variables. To perform this analysis, we take data on the reliability of small arms trade from the Small Arms Exports Transparency Barometer. This barometer database was introduced in 2003 but includes data starting in 2000. The Small Arms Survey defines transparency as "states produce complete, full, accurate, comprehensive, and timely reports on the small arms and light weapons export licenses they have issued and actual weapons they have delivered." The transparency score given to a country is based on 3 sources: national arms export reports, reporting to the UN Register, and UN customs data. The data show that the mean score of transparency in reporting improved from 7.95 to 11.47 points for the period 2001-2008. In addition, 8 countries had a transparency score of 0 in 2001, while only 2 countries have a score of 0 in 2008: Iran and North Korea. Based on these results, we can see that transparency in small arms exports reporting has greatly increased from 2001-2008. Thus, if transparency has improved, our small arms trade volume per year should be biased upward. Recall that our models estimate the ratio of average arms trade during 2005-2008 over the average arms trade during 1998-2004. If our data for arms trade were biased upward, this would only make the ratio smaller.

7. Conclusion

A large denomination of paper notes has long been advantageous for criminal organizations as it facilitates black market transactions (Rogoff, 2016). We suspect that criminal groups around the world generally detain a large quantity of money. Hence, the introduction of the euro currency in 2002, which affected twelve former currencies, must have touched numerous illicit organizations. They had no other choice than to convert their money into another currency or into something else.

However, trying to exchange a large quantity of one currency in a short period of time is hard. Therefore, they were left with the second option: using their cash to buy assets. We believe one of the goods that might have been bought to get rid of their large amount of paper money are small arms.

The literature review indicates that there was a gap in research on the impact of the introduction of the euro currency and the arms trade imports. Fieleke (1991), found that arms imports were not correlated to military expenditures. In addition, scholars agree that the arms trade are decreasing socio-economic development as nations decide to use more of their limited resources to buy arms instead of investing in wellbeing and learning (Powell 2004). Most studies have focused on arms trade without special attention for small arms trade. However, the small arms trade category is responsible for 0.5 million fatalities each year. Thus, figuring out which variables play a role in predicting arms transfer is primordial. As well, our study was motivated by discovering a new consequence of the establishment of the monetary union in Europe.

This paper explored the impact of the creation of the euro currency on the arms trade imports in countries with close ties to the euro as opposed to those with weak ties. Our main hypothesis was that countries around the world holding former national currency that would be replaced by the euro would have to find ways to exchange their money before the time limit and sometimes they could not go to the bank. Moreover, we believed that countries with a high percentage of imports coming from the twelve countries going through the euro currency changeover would have seen their arms trade imports increase before the currency change. Indeed, we found that the average arms trade after the introduction of the euro over the average arms trade before was higher for countries with a higher percentage of total imports coming from the twelve

Euro countries. Whereas population growth and GDP growth from 1998-2008 were not shown to have a significant effect on the ratio of arms trade.

Another interesting finding was that the population growth from 1988-1998 was significantly different from 0. This suggested that population growth 10 years prior could help explain variation in arms trade better than the concurrent population growth. Intuitively this result makes a lot of sense since most of the population growth is due to birth and 0-10 years old usually are not the one buying or holding a gun.

To verify the reliability of our results we tested our variables for multicollinearity in various ways and we tested for robustness as well. According to the correlation matrix, the consistent signs of our regressors and the variance inflation factor, our independent variables are not highly correlated together. Similarly, we verified the strength of our model by removing variables. The results also indicated that the I_{euro}, as well as $A * I_{euro}$ variables, seem robust to the omissions of variables.

Appendix

Transformation	formula	chi2(2)	P(chi2)
cubic	R^3	.	0.000
square	R^2	.	0.000
identity	R	.	0.000
square root	sqrt(R)	.	0.000
log	log(R)	6.29	0.043
1/(square root)	1/sqrt(R)	.	0.000
inverse	1/R	.	0.000
1/square	1/(R^2)	.	0.000
1/cubic	1/(R^3)	.	0.000

FIGURE 2.1 Ladder resutls for R

Transformation	formula	chi2(2)	P(chi2)
cubic	I_euro^3	.	0.000
square	I_euro^2	.	0.000
identity	I_euro	66.31	0.000
square root	sqrt(I_euro)	.	0.000
log	log(I_euro)	.	0.000
1/(square root)	1/sqrt(I_euro)	.	0.000
inverse	1/I_euro	67.58	0.000
1/square	1/(I_euro^2)	.	0.000
1/cubic	1/(I_euro^3)	.	0.000

FIGURE 2.2 Ladder results for I_euro

Transformation	formula	chi2(2)	P(chi2)
cubic	A_Ieuro^3	.	0.000
square	A_Ieuro^2	.	0.000
identity	A_Ieuro	67.58	0.000
square root	sqrt(A_Ieuro)	22.94	0.000
log	log(A_Ieuro)	31.03	0.000
1/(square root)	1/sqrt(A_Ieuro)	29.04	0.000
inverse	1/A_Ieuro	.	0.000
1/square	1/(A_Ieuro^2)	.	0.000
1/cubic	1/(A_Ieuro^3)	.	0.000

FIGURE 2.3 Ladder results for A_Ieuro

Transformation	formula	chi2(2)	P(chi2)
cubic	corr_I~o^3	.	0.000
square	corr_I~o^2	.	0.000
identity	corr_I~o	37.59	0.000
square root	sqrt(corr_I~o)	16.71	0.000
log	log(corr_I~o)	55.63	0.000
1/(square root)	1/sqrt(corr_I~o)	27.85	0.000
inverse	1/corr_I~o	29.62	0.000
1/square	1/(corr_I~o^2)	73.47	0.000
1/cubic	1/(corr_I~o^3)	.	0.000

FIGURE 2.4 Ladder results for corr_Ieuro

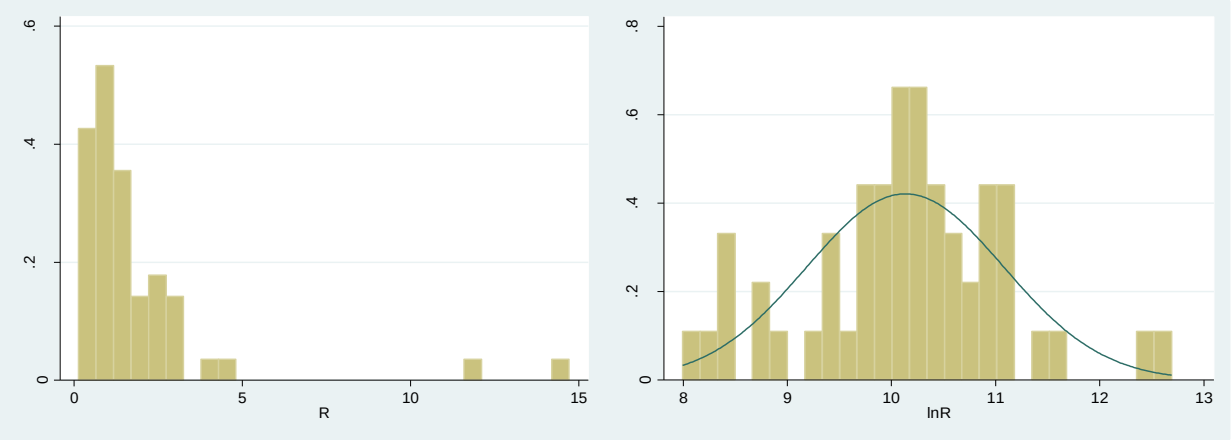

FIGURE 3.1 Histogram of R (left) and Histogram of lnR (right)

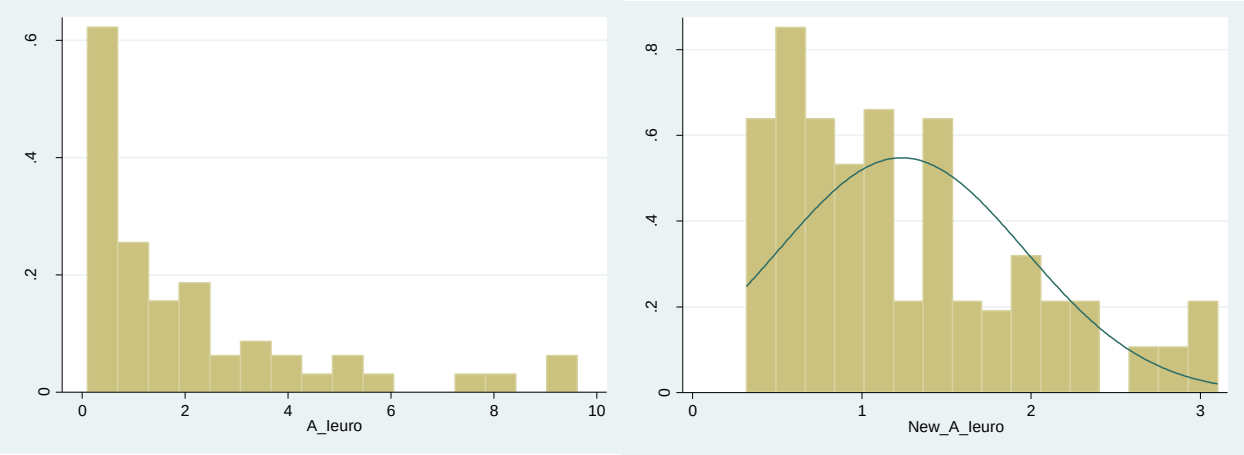

FIGURE 3.2 Histogram of A_Ieuro (left) and Histogram of the square root of A_Ieuro (right)

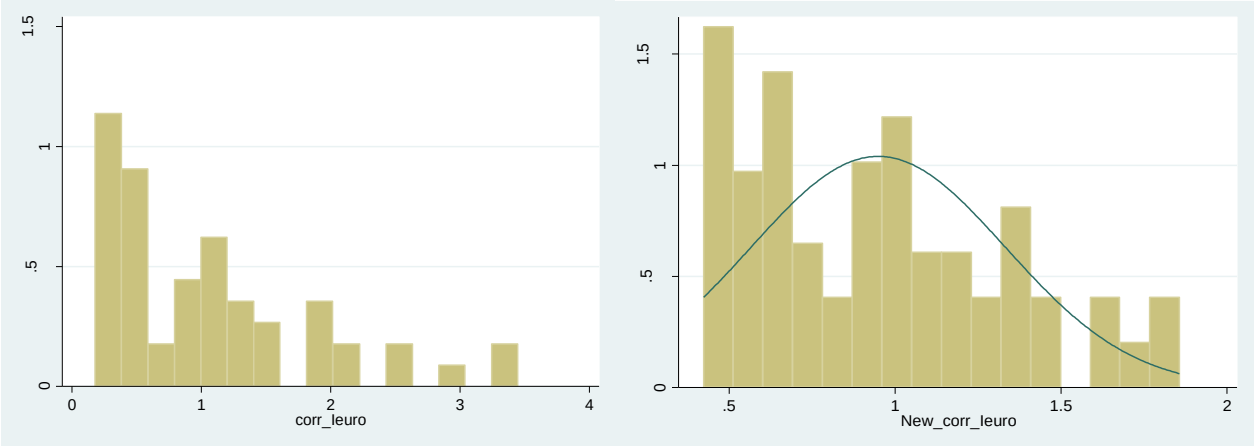

FIGURE 3.3 Histogram of corr_Ieuro (left) and Histogram of the square root of corr_Ieuro (right)

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