THE TRANSATLANTIC RELATIONSHIP BETWEEN INFLATION AND EXCHANGE RATES AND HOW IT HAS CHANGED

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Abstract

While the literature suggests a depreciating effect on the exchange rate when relative inflation rises, this empirical study which uses the VAR model shows no sign of this relationship. Before the pandemic, money supply and exchange rates did have Granger causality and thus predictive power over each other. This has also disappeared since the coronavirus hit our economies. This points to noise in the data.

Table of contents

1. Introduction

1976 Nobel Prize winner Milton Friedman once famously said “Inflation is always and everywhere a monetary phenomenon.” Before then and ever since inflation and its effect on society have been widely studied in the field of economics. This thesis will be an addition to the existing literature where I will study the relationship (R) between inflation difference and the exchange rate and to be more precise the effect of the former on the latter. The role of the Covid-19 pandemic will also be looked at. I will be examining the effect of inflation differences between the Eurozone and the US on the EURO-USD exchange rate. These are two major economies, And a major trading partner of each other (European Parliament, 2021) (Branch, 2021) making their exchange rate a vital part of economic analysis. This relationship R was among others described by Dornbusch (1987) But how valid is the explanation of this relationship R where a higher inflation than the adversary currency area causes a depreciation relative to the adversary area between the US and the EU? And has R changed since the pandemic started? Both the European Central Bank (ECB) and the Federal Reserve System of the US are printing unprecedented amounts of money into the economy (European Central Bank, 2021), inflation is becoming more and more uneven: housing costs are rising far higher in recent years. In the last quarter of 2020 the eurozone housing prices were 5.4% higher than the same quarter in 2019. (Housing Price Statistics - House Price Index - Statistics Explained, 2021). Also, stocks appear expensive in many places. While the average inflation keeps rising in the Eurozone, it is not yet at the level of the before named sections such as housing and stocks. In the last 2 quarters, average inflation rose to 1.3% (HICP inflation forecasts, n.d.). On the other side of the Atlantic, the US inflation is rising stronger. This resulted in the inflation difference rising from 1.5% point in October 2020 to 3.5% point in June 2021 (*Trading Economics*, z.d.). Meanwhile, the EUR-USD exchange rate changed from 1.18 Dollar per Euro to around 1.20 Dollar per euro in June 2021 (*ECB Statistical Data Warehouse*, 2021).

On the eye, this shows no relationship R. However, it should be noted there have been some shocks between this timeframe and the central banks and governments have much more to combat the economic atrocities of the pandemic than what is captured in the inflation rate. In the year before the pandemic, from February 2019 to February 2020, the inflation difference rose from 0.38% point to 1.45% point. The exchange rate changed from 1.13 to 1.11 Dollar per Euro, coming a bit closer to a clear relationship. With this in mind, how and whether this appreciation/depreciation effect explained by Dornbusch (1987) and others has changed might not be sufficiently considered. Also, since 1987 the estimation models used have changed. While the Vector Auto Regression (VAR) model which I will use was first introduced by Sims (1980), Dornbusch did not use nor mention the model in his 1987 book where he introduced the relationship between inflation and exchange rates (Monfared & Akin, 2017). Therefore, the effect might be estimated better via the modern econometric tools and computers I have at my disposal. That is why my research question will be:

"What is the effect of inflation difference on the exchange rate between the EU and the United States and has this effect changed?"

From what I've learned from the literature, a higher inflation than the adversary currency area causes a depreciation relative to the adversary area. This effect may have changed during the Covid-19 pandemic since the federal reserve systems of both currency areas have gone to great lengths stabilizing their economies which troubles the view of such effects on the exchange rate.

"A higher relative inflation leads to a depreciation and this effect has changed recently"

The research question and hypothesis will be explained further in the theoretical framework, where the current literature is explored and economic principles are clarified. After that, the data will be detailed and the methodology explained. After the analysis I will come back to the hypothesis.

2. Theoretical framework

2.1. Inflation

To begin to understand inflation two kinds of inflation have to be distinguished between: demand-pull inflation and cost-push inflation (Barth & Bennett, 1975). In the theory of demand-pull inflation it is believed inflation is caused by a low unemployment and thus more consumers having disposable income. This creates a high demand which could surpass supply. In this case, suppliers raise prices which in turn increases the cost of living. This increase in demand creates the need for more workers to upkeep the supply, eventually causing demand to outpace the aggregate supply again. Demand-pull inflation can also be caused and explained by e.g. a rising trust in the economy by consumers, a rise in exports, an increase in money supply and a government spending their money more freely increasing government expenditure.

This explanation for inflation follows the quantity theory of money (Dutta, 2015). The workings of the money supply are best explained by the Fisher equation first mentioned by him in 1911:

MV=PT with M = Money supply, V = Velocity of money, P = Price level and T = Amount of transactions.

However, because the amount of transactions is difficult to calculate, it is popularly replaced by Y = Real output. This results in the most commonly used Fisher equation :

$$MV=PY$$

The equation shows the mechanism of the amount of money circulating the economy times the velocity of said circulation must equal the price level times the real output. One may notice both sides of the equation equal the nominal GDP. In the short term, Fisher assumed the velocity is constant in the short term. And since an increase in money never affects the real output, an increase in the money supply always results in an increase in the price level and thus causes inflation. Because of this direct effect money supply is included as a control variable. However, there are multiple ways to show the money supply. These definitions are listed below (ECB, 2021):

- M0: Cash currency in circulation
- M1: M0 + overnight deposits
- M2: M1 + deposits with an agreed maturity of ≤ 2 years and deposits redeemable at notice of ≤ 3 months
- M3: M2 + repurchase agreements, money market fund shares and debt securities with a maturity of ≤ 2 years

In this paper, M2 is used. I made this choice because it is less volatile and include more than M0 and M1. Another option was M3, but it among other things also includes large time deposits and institutional market funds, which I found not very relevant for inflation of goods, since they are not at all liquid and can not react to exchange rate changes.

Cost-push inflation occurs differently than demand-pull inflation. In this theory, inflation is caused not by demand but by higher market power that permits either wages to be raised by strong labour unions which results in higher costs for producers which are passed down to consumers or prices that are increased by oligopolistic firms (Barth & Bennett, 1975). In this case money supply growth would be rather passive and less important in determining the inflation rate. Knowing this, it can be concluded cost-push inflation is less determined by the government and central banks. This is in contrast to demand-pull inflation, where these bodies have more of an influence. The rest of this thesis will assume the inflation which may or may not affect the exchange rate is demand-pull inflation, which can be easily influenced by the respective central banks of the US and the Eurozone.

2.2. Relationship between inflation and Exchange rates

An exchange rate is essentially the value of a currency denoted in another. For example, according to the European Central Bank (2021) on June 1st one could trade 1 EUR for 1.22 USD. In the most commonly used notation this is written from an European perspective as 1.22 €/$.

The relationship can be explained in the direct and indirect sense. The direct explanation is via Purchasing Power Parity (PPP), which means every good and service should cost the same in every country when the cost is denoted in the same currency. This would mean the nominal price of a good should decrease when the relative exchange rate appreciates. While the theory has proven useful in furthering the understanding of trade economics, PPP assumes all goods and services are tradable and traded, which is far from the case. Also tariffs, transportation cost and other trade barriers keep PPP from holding in the real world.

When Dornbusch (1987) first described the indirect relationship between inflation and exchange rates (Monfared & Akin, 2017) he explored interesting new ground which has since become textbook material and is explained as followed: when the relative prices of the home country rise, more products and services are bought in the foreign country as they are cheaper

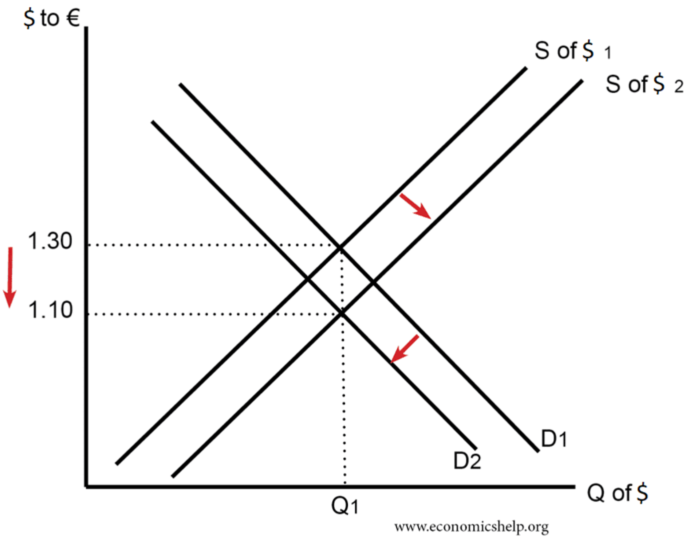

Figure 1: the effect of inflation on exchange rates (Pettinger, 2019c) and edited by the author.

there. Because of this the demand for the home currency would fall, resulting in a foreign appreciation and a domestic depreciation. Figure 1 shows a situation where the demand of the Dollar drops, which in turn means a lower value of the dollar against the euro.

There are also voices claiming the reverse effect. For example, Woo and Hooper (1984) claim exchange rates can affect inflation rates and name four channels via which this effect is possible:

- Prices of imported consumer goods directly affecting the consumer price index (CPI)
- Prices of imported inputs, directly affecting costs of production
- Exchange rate movements making domestic product prices less attractive and thus affecting aggregate demand and the current account
- Foreign prices affecting the prices of domestically produced competing goods

Another route of exchange rates influencing prices is the exchange rate pass-through. Campa & Goldberg (2005) have introduced a model which is explained as followed: when the currency of the exporting country appreciates, costs rise for the importing country. This brings extra costs which must be absorbed somewhere. Their estimation of the effect of the exchange rate on production costs and thus import prices is mathematically described in the following equation:

$$p_t = \alpha + \delta w_t + \beta e_t + \varphi y_t + \epsilon_t$$

In this equation, p_t are local currency import prices, w_t is described as the primary "control" variable representing exporter costs and y_t are other control variables including the real GDP of the destination market. e_t is the fluctuation of the exchange rate and β the share of exchange rate costs which are passed through to import prices. β is decided by market structure and competition. When $\beta = 0$ all costs are absorbed by exporters' markups and when $\beta = 1$ all costs are carried by the importing party.

2.3. Empirical conclusions

While it seems no studies have been done about the effect of inflation on exchange rate between specifically the Eurozone and the US. The relationship has been studied in other countries and currency areas, mainly concluding the reverse effect is true: exchange rates affect the inflation.

The European Journal of Sustainable Development published an article in which Monfared & Akin (2017) studied the relationship between exchange rates and inflation in Iran. They concluded through a variance decomposition the contribution of exchange rates to inflation only amounted to 1.33%. This is very limited when money supply and the inflation in the time period before accounted for respectively 62.11 and 36.54%.

While this paper will look at total inflation, Woo and Hooper (1984) studied the relationship between the American exchange rate and non-fuel, non-food inflation. They concluded that while the strong dollar and the high relative prices for foreign countries hurt the American economy in the early 1980's, the primary determinant of the inflation were wage demands and oil prices. This puts the paper in the cost-push inflation school of thought. However, in the general discussion which was included in the paper it was mentioned by multiple commenters that this is not so clear-cut as stated by Woo and Hooper. For example Richard Cooper, former chairman of the Federal reserve bank of Boston, was "sceptical about the absence of exchange rate effects in the pricing of domestically produced goods. So many complaints from the steel, textile, and automobile industries about competitive pressures from imports testify to the contrary." Cooper also stated by keeping prices above the free trade level the quotas effectively eliminated the impact of the exchange rates.

When Campa & Goldberg (2005) studied the exchange rate pass-through in a large sample of OECD countries using cross-country time series they found import prices reflect 46% of the exchange rate fluctuations in the short-term and nearly 65% in the long-run. In the US this changes to 23% and 42%. When the OECD is looked at as one country, in the long run the elasticity is close to 1 and thus $\beta = 1$. This would mean in the long run a relative deprecation causes a relative inflation. This confirms Dornbusch but in the opposite direction.

In The Journal of Monetary Economics Devereux & Engel (2002) state that while former economists claimed exchange rate pass-trough declined as exchange rate volatility rose, exchange rate fluctuations matter very little in the grand scheme of macroeconomics. The model set up in the paper shows high exchange rate volatility has close to no effect on other economic aggregates. This confirms the well-known exchange rate disconnect puzzle which implies the weak short-run relationship between the exchange rate (volatility) and economic variables such as interest rates, inflation and output.

3. Data

To study the relationship between inflation, I used the following monthly data:

- EUR/USD exchange rate average (*ECB Statistical Data Warehouse*, 2021)
- US HICP inflation Index data (*FRED Economic Data*, 2021)
- EU HICP inflation Index data (*FRED Economic Data*, 2021)
- US M2 Money supply in billions of Dollars data (*FRED Economic Data*, 2021)
- EU M2 Money supply in millions of Euros data (*ECB Statistical Data Warehouse*, 2021)

While daily exchange rate data is available it is not useful since it is the only variable available in this way. So, only monthly data can be used. I used Harmonized Index of Consumer Prices Inflation data because HICP data is designed to be internationally comparable. I used Index data with 2015=100 and not monthly percentages so earlier price changes are not forgotten in the inflation data, since earlier exchange rate changes also stay in the exchange rate. If monthly annualized percentages were used, these time series would not be compatible. Money supply is used as a control variable since it has a direct effect on inflation as shown in the theoretical framework by Fisher's equation.

By creating variables in which the difference between the two areas is shown these differences can be used in the model. The following variables were created:

- US Inflation Index minus EU inflation Index = Monthly inflation difference
- US M2 Money supply in billions of Euros using each month's average exchange rate
- EU M2 Money in billions of Euros
- US M2 divided by EU M2 = Money supply factor

The first dataset spreads from December 2001 to March 2021 for every variable because this was the available overlap between the data. In the second dataset I removed the data from March 2020 onwards to see if the results would be different had I done this before the strange times of the pandemic.

3.1. Descriptive statistics

Table 1 shows the Mean, standard deviation, minimum and maximum of the first dataset ranging from December 2001 up and until March 2021.

Variable	**Obs.**	**Mean**	**St. Dev.**	**Min**	**Max**
EUR/USD	232	1.24	0.14	0.87	1.58
USHICP	232	93.50	9.95	74.09	109.55
EUHICP	232	94.16	8.23	78.36	106.53
*USM2Euros**	232	8393	3359	4791	16899
*EUM2Euros**	232	8578	2436	4589	13915
HICPDiff	232	0.66	1.89	-3.02	4.50
M2Factor	232	1.07	0.19	0.74	1.56

*Table 1: Descriptive statistics of the first dataset. *In billion Euros.*

The means can be interpreted as followed: on average, from December 2001 up and until March 2021:

- 1 Euro could be traded for 1.24 Dollar
- Consumer prices were 93.5% of the 2015 index in the US
- Consumer prices were 94.16% of the 2015 index in the EU
- M2 Money supply in the US tallied 8393 billion Euros
- M2 Money supply in the EU tallied 8578 billion Euros
- In the US, consumer prices were 0.66 percentage point higher than their 2015 index compared to the prices in the EU compared to their respective 2015 index
- M2 Money supply in the EU was 107% of the EU M2 Money supply

Table 2 shows the mean, standard deviation, minimum and maximum of the second dataset, ranging from December 2001 up and until February 2020.

Variable	Obs.	Mean	St. Dev.	Min	Max
EUR/USD	219	1.24	0.14	0.87	1.58
USHICP	219	92.68	9.65	74.09	106.9
EUHICP	219	93.49	7.98	78.36	105.15
*USM2Euros**	219	7931	2851	4791	14685
*EUM2Euros**	219	8297	2204	4589	12419
HICPDiff	219	0.80	1.84	-2.12	4.50
M2Factor	219	1.08	0.19	0.74	1.56

*Table 2: Descriptive statistics of the second dataset. *in billion euros.*

In this dataset, there are some notable differences:

- The US money supply has slowly been catching up to that of the Eurozone
- In line with theory, US inflation has risen more quickly in comparison to the Eurozone
- The exchange rate data has not notably changed by removing pandemic data

Furthermore, since the VAR model which is used requires logarithmic variables, the following variables were generated in Stata.

- Ln EURUSD
- Ln Inflation Difference = Ln EU Inflation – Ln US Inflation
- Ln M2 Difference = Ln EUM2 – Ln USM2

4. Econometrical techniques

In the following chapters of this research, several econometric techniques will be used. Before implementation I will explain:

- The Vector Auto Regression model (VAR)
- The Akaike's information criterion (AIC)), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC)
- Augmented Dickey-Fuller test (ADF)
- Granger causality

The VAR model, first introduced by Sims (1980), creates the possibility to find correlations between time series. It uses not only the current values, but defines the current value in terms of its own lags and those of the other variables included. This makes it a logical method for me to use since I want to use multiple time series and want the lagged values to be included so the estimation is as complete as possible. With the VAR model, the following equations are set up:

$$y_{1t} = c_1 + \sum_{i=1}^{257} \pi_{11}^{i} y_{1\,t-i} + \pi_{12}^{i} y_{2\,t-i} + \pi_{13}^{i} y_{3\,t-i} + \epsilon_{1t}$$

$$y_{2t} = c_2 + \sum_{i=1}^{257} \pi_{21}^{i} y_{1\,t-i} + \pi_{22}^{i} y_{2\,t-i} + \pi_{23}^{i} y_{3\,t-i} + \epsilon_{2t}$$

$$y_{3t} = c_3 + \sum_{i=1}^{257} \pi_{31}^{i} y_{1\,t-i} + \pi_{32}^{i} y_{2\,t-i} + \pi_{33}^{i} y_{3\,t-i} + \epsilon_{3t}$$

In the equations above, the π Is the estimation coefficient and y is the estimated variable. For example, $\pi_{12}^{3} y_{2\,t-3}$ is the predicted effect of the third lag of the second variable on the first variable. c_x is the constant and ϵ_{xt} is the error term. In this model, the three variables would be the natural logarithm of the exchange rate, natural logarithm of the inflation difference and the natural logarithm of the M2 difference.

To use the VAR model, the error term must have a mean of zero, and serial correlation within the error terms may not exist. To ensure this, the right amount of lags must be chosen. This is done using the Lag-order selection command in Stata. This gives us several criteria: the AIC, SBIC and the HQIC

(Varsoc manual, n.d.). The Stata command gives a negative value for each of the lags for each of the criteria. The lag number corresponding to the lowest number of whichever of the criteria is the most accurate.

This model also assumes the time series is stationary and if not then it must be stationary at first difference (Sims, 1980) So, a stationary test is needed. A time series is stationary when the way it changes does not change over time. To test this I will use the ADF test. This test is used and not the standard Dickey-Fuller test because only ADF allows for multiple lags. The test has the following null hypothesis: there is a unit root in an AR model. Only when the test value is further below zero than the critical value the null hypothesis is rejected which implies the time series is stationary and thus suitable for the VAR model.

With a VAR model which meets the assumptions Granger causality can be tested. Granger causality from variable 1 to 2 implies the lags of variable 1 have predictive force over variable 2 and this predictive information is not contained by variable 2’s own lags.

5. Methodology

In this chapter the econometric techniques and tests will be implemented and if the VAR model is proven suitable for use, we will continue with the results.

Using the lag-order selection in Stata, AIC gives us the lowest values in both datasets so this criteria will be used. The results of this test are shown in figures 3 and 6 for respectively datasets 1 and 2. Both figures are shown in the appendix.

To confirm stationarity, the ADF test is used. In this test, the number of lags must be specified. For this dataset, the AIC set the ideal number of lags at 3.

Variable	**Test statistic**	**Critical value**
Exchange rate logarithm	-3.270	-2.882
Inflation difference logarithm	-2.206	-2.882
M2 Difference logarithm	-1.728	-2.882

Table 3: Augmented Dickey-Fuller test for dataset 1 until March 2021, critical values at 5%.

With these values the null hypothesis of the augmented Dickey-Fuller test can not be rejected. The failure of rejection implies that the time series is not stationary. This is why an ADF test at first difference must be performed to test whether a VAR model can be used. This gives the following results:

Variable	**Test statistic**	**Critical value**
Exchange rate logarithm	-6.273	-2.882
Inflation difference logarithm	-8.169	-2.882
M2 Difference logarithm	-6.312	-2.882

Table 4: Augmented Dickey-Fuller test with first-differences for dataset 1 until March 2021, critical values at 5%.

The null hypothesis is rejected. So, the first dataset is proven stationary at first difference and thus proven suitable for VAR.

For the second dataset AIC set the ideal number of lags at 4 as shown in figure 6 in the appendix. In this case too, the stationarity is tested using the ADF test:

Variable	Test statistic	Critical value
Exchange rate logarithm	-3.162	-2.882
Inflation difference logarithm	-2.152	-2.882
M2 Difference logarithm	-1.924	-2.882

Table 5: Augmented Dickey-Fuller test for dataset 2 until February 2020, critical values at 5%

Again, the null hypothesis can not be rejected with these values and stationarity is not proven. So, again an Augmented Dickey-Fuller test at first difference is performed to test whether a VAR model can be used.

Variable	Test statistic	Critical value
Exchange rate logarithm	-5.930	-2.882
Inflation difference logarithm	-8.009	-2.882
M2 Difference logarithm	-5.612	-2.882

Table 6: Augmented Dickey-Fuller test at first difference for dataset 2 until February 2020, critical values at 5%

This test rejects the null hypothesis and shows the variables to be stationary at first difference and thus both datasets are suitable for the VAR model. Because the VAR model can be used, Granger causality can also be used to test if the model has any predictive force. The results will be analysed in the next chapter.

6. Results & Analysis

For the 2001-2021 dataset the VAR model estimations are shown in figure 4 in the appendix. It shows 5 significant correlations at the 5% level:

- The first lag of the exchange rate on the exchange rate
- The first three lags of the inflation difference on the inflation difference
- The first lag on the M2 difference on the M2 difference

For the 2001-2020 dataset the VAR model estimations are shown in figure 7 in the appendix. It shows 8 significant correlations at the 5% level:

- The first, third and fourth lag of the exchange rate on the exchange rate
- The third and fourth lag of the M2 difference on the exchange rate
- The first and second lag of the inflation difference on the inflation difference
- The third lag of the exchange rate on the M2 difference
- The first lag of the M2 difference on the M2 difference

For the other lags no effect can be concluded. It shows the variables are mostly affected by their own lags.

Table 3 confirms the lack of correlations between variables in the first dataset. At the 5% significance level there is no provable causality between any of the variables. At the 10% significance level however, there is a causal relationship in the direction from the M2 difference to inflation. Still, Granger causality is rejected.

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	P-VALUE
EXCHANGE RATE	Inflation difference	0.408
	M2 difference	0.559
INFLATION DIFFERENCE	Exchange rate	0.126
	M2 Difference	0.720
M2 DIFFERENCE	Exchange rate	0.146
	Inflation difference	0.287

Table 3: Granger causality test for the VAR model of dataset 1 until March 2021

Table 4 however does show Granger causality between the M2 difference and the EUR/USD exchange rate in both directions at the 5% significance level. The Inflation difference is not involved in any causality, not at a 5% nor at a 10% significance level. Graphically, this is shown in figure 2 below.

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	P-VALUE
EXCHANGE RATE	Inflation difference	0.450
	M2 difference	0.023
INFLATION DIFFERENCE	Exchange rate	0.648
	M2 Difference	0.661
M2 DIFFERENCE	Exchange rate	0.037
	Inflation difference	0.414

Table 4: Granger causality test for the VAR model of dataset 2 until February 2020

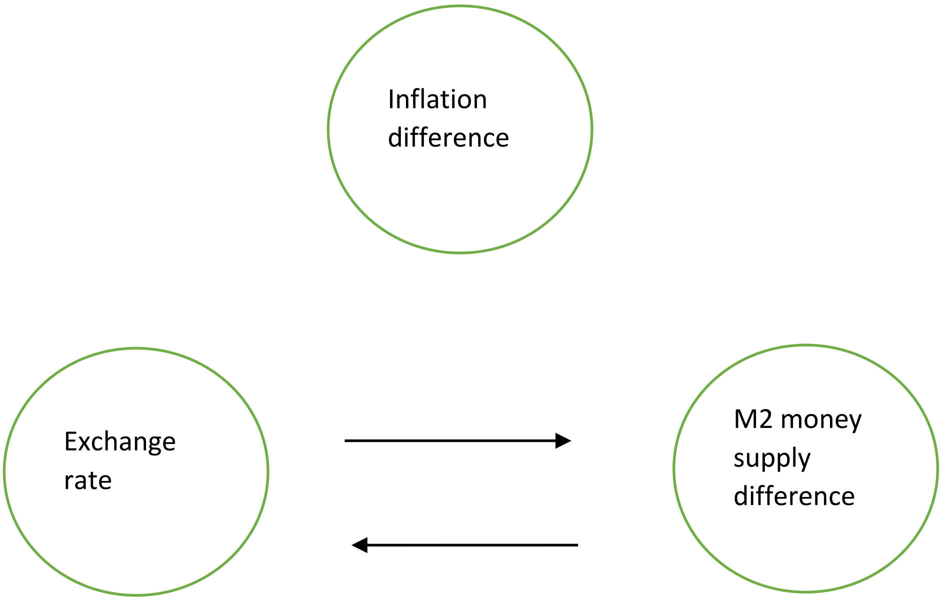

Figure 2: Granger causality in dataset 2 until February 2020 visualized

7. Conclusion & Discussion

In the introduction, the following hypothesis was stated:

"A higher relative inflation leads to a depreciation and this effect has not changed recently"

In my findings, no (Granger) causality nor correlation was found between the relative inflation and changes in the exchange rate whether or not the pandemic is included in the dataset, contrary to popular theory. So, the hypothesis can not be confirmed.

However, this does not mean my findings are without interesting takeaways: There is Granger causality between the M2 difference and the exchange rate in both directions in the second dataset without the pandemic only. This shows the predictive power of the money supply difference was present before the pandemic, but has since significantly decreased. This noise in the data makes it harder to predict future trends. It is unclear for how long this noise will stay.

There are some opportunities for future studies. While the noise in the data is clear, it is unclear where it comes from. If we know where it comes from, we will most likely also know when it will end. Furthermore, I used index inflation data. It could be tested whether using monthly annualized percentages is more suitable.

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9. Appendix

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1097.89				1.1e-08	-9.77581	-9.75736	-9.73011
1	2275.41	2355	9	0.000	3.4e-13	-20.209	-20.1353	-20.0263
2	2340.45	130.08	9	0.000	2.0e-13	-20.7094	-20.5803*	-20.3895*
3	2354.28	27.665	9	0.001	1.9e-13*	-20.7525*	-20.5681	-20.2956
4	2363.03	17.495*	9	0.042	2.0e-13	-20.7503	-20.5105	-20.1563
5	2367.38	8.6991	9	0.466	2.0e-13	-20.7088	-20.4137	-19.9777
6	2373.37	11.972	9	0.215	2.1e-13	-20.6818	-20.3314	-19.8137
7	2380.4	14.066	9	0.120	2.1e-13	-20.6643	-20.2585	-19.6591
8	2385.1	9.392	9	0.402	2.2e-13	-20.6259	-20.1648	-19.4836

Figure 3: Lag-order selection for dataset 1 until March 2021

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnEURUSD						
lnEURUSD						
L1.	1.066281	.2647366	4.03	0.000	.5474062	1.585155
L2.	-.2274651	.4481708	-0.51	0.612	-1.105864	.6509335
L3.	.0832147	.2689112	0.31	0.757	-.4438415	.610271
lnInflDiff						
L1.	.4421532	.3419605	1.29	0.196	-.2280772	1.112384
L2.	-.7354763	.5559633	-1.32	0.186	-1.825144	.3541918
L3.	.3886896	.3316059	1.17	0.241	-.2612461	1.038625
lnM2Diff						
L1.	.1962996	.2586725	0.76	0.448	-.3106893	.7032884
L2.	-.1356808	.4416568	-0.31	0.759	-1.001312	.7299506
L3.	-.0317901	.2623469	-0.12	0.904	-.5459805	.4824003
_cons	.0148952	.0082676	1.80	0.072	-.0013091	.0310994
lnInflDiff						
lnEURUSD						
L1.	.0427107	.049997	0.85	0.393	-.0552815	.140703
L2.	-.0942956	.0846395	-1.11	0.265	-.260186	.0715949
L3.	.034475	.0507854	0.68	0.497	-.0650625	.1340125
lnInflDiff						
L1.	1.482847	.0645811	22.96	0.000	1.35627	1.609424
L2.	-.7817268	.1049968	-7.45	0.000	-.9875166	-.5759369
L3.	.2631197	.0626256	4.20	0.000	.1403758	.3858637
lnM2Diff						
L1.	-.0827347	.0488517	-1.69	0.090	-.1784823	.013013
L2.	.1318678	.0834093	1.58	0.114	-.0316114	.2953471
L3.	-.0390809	.0495457	-0.79	0.430	-.1361886	.0580268
_cons	.0030304	.0015614	1.94	0.052	-.0000299	.0060907
lnM2Diff						
lnEURUSD						
L1.	-.430445	.2719645	-1.58	0.113	-.9634856	.1025957
L2.	.3511214	.4604068	0.76	0.446	-.5512593	1.253502
L3.	.0116469	.276253	0.04	0.966	-.5297991	.5530929
lnInflDiff						
L1.	.390799	.3512968	1.11	0.266	-.29773	1.079328
L2.	-.4792946	.5711423	-0.84	0.401	-1.598713	.6401237
L3.	.2395034	.3406595	0.70	0.482	-.4281769	.9071837
lnM2Diff						
L1.	1.689664	.2657349	6.36	0.000	1.168833	2.210495
L2.	-.7016811	.4537149	-1.55	0.122	-1.590946	.1875838
L3.	.0367171	.2695095	0.14	0.892	-.4915118	.564946
_cons	.0120087	.0084934	1.41	0.157	-.004638	.0286554

Figure 4: VAR model estimates of dataset 1 until March 2021, 229 observations.

Equation	Excluded	chi2	df	Prob > chi2
lnEURUSD	lnInflDiff	2.8965	3	0.408
lnEURUSD	lnM2Diff	2.0639	3	0.559
lnEURUSD	ALL	10.123	6	0.120
lnInflDiff	lnEURUSD	5.7286	3	0.126
lnInflDiff	lnM2Diff	6.9973	3	0.072
lnInflDiff	ALL	16.082	6	0.013
lnM2Diff	lnEURUSD	5.3853	3	0.146
lnM2Diff	lnInflDiff	3.7708	3	0.287
lnM2Diff	ALL	21.448	6	0.002

Figure 5: Granger causality test for dataset 1 until March 2021, Stata output

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1080.09				7.4e-09	-10.2094	-10.1902	-10.1618
1	2197.48	2234.8	9	0.000	2.0e-13	-20.7155	-20.6384	-20.5248
2	2240.01	85.065	9	0.000	1.5e-13	-21.0333	-20.8985*	-20.6997*
3	2252.82	25.617	9	0.002	1.4e-13	-21.0694	-20.8768	-20.5928
4	2264.13	22.623	9	0.007	1.4e-13*	-21.0913*	-20.8409	-20.4718
5	2269.33	10.388	9	0.320	1.4e-13	-21.0552	-20.747	-20.2927
6	2273.98	9.3077	9	0.409	1.5e-13	-21.014	-20.648	-20.1086
7	2284.48	20.998*	9	0.013	1.5e-13	-21.0283	-20.6044	-19.9798
8	2288.69	8.4247	9	0.492	1.6e-13	-20.9829	-20.5013	-19.7915

Figure 6: Lag-order selection for dataset 2 until February 2020

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnEURUSD						
lnEURUSD						
L1.	.9005852	.3727691	2.42	0.016	.1699711	1.631199
L2.	-.495487	.5752917	-0.86	0.389	-1.623038	.6320641
L3.	1.303357	.5584716	2.33	0.020	.2087732	2.397941
L4.	-.8534076	.3627719	-2.35	0.019	-1.564427	-.1423878
lnInflDiff						
L1.	.3767942	.3571417	1.06	0.291	-.3231907	1.076779
L2.	-.5206655	.6418802	-0.81	0.417	-1.778727	.7373965
L3.	-.1194925	.6473144	-0.18	0.854	-1.388205	1.14922
L4.	.3565363	.3572098	1.00	0.318	-.3435821	1.056655
lnM2Diff						
L1.	.3475523	.3655797	0.95	0.342	-.3689708	1.064075
L2.	.1303661	.561801	0.23	0.816	-.9707436	1.231476
L3.	-1.22975	.5484642	-2.24	0.025	-2.30472	-.1547803
L4.	.8288404	.3574018	2.32	0.020	.1283457	1.529335
_cons	.0249169	.0092618	2.69	0.007	.0067641	.0430696
lnInflDiff						
lnEURUSD						
L1.	-.0326895	.0726741	-0.45	0.653	-.1751281	.1097492
L2.	.0271381	.1121574	0.24	0.809	-.1926865	.2469626
L3.	.0358514	.1088782	0.33	0.742	-.177546	.2492487
L4.	-.0450732	.0707251	-0.64	0.524	-.1836918	.0935455
lnInflDiff						
L1.	1.485587	.0696275	21.34	0.000	1.34912	1.622055
L2.	-.7714451	.1251393	-6.16	0.000	-1.016714	-.5261765
L3.	.2401251	.1261988	1.90	0.057	-.00722	.4874702
L4.	.0138599	.0696407	0.20	0.842	-.1226334	.1503532
lnM2Diff						
L1.	-.0079305	.0712725	-0.11	0.911	-.147622	.1317611
L2.	.018205	.1095273	0.17	0.868	-.1964646	.2328745
L3.	-.0594677	.1069272	-0.56	0.578	-.2690411	.1501058
L4.	.0577313	.0696782	0.83	0.407	-.0788353	.194298
_cons	.0026222	.0018057	1.45	0.146	-.0009168	.0061612
lnM2Diff						
lnEURUSD						
L1.	-.2737607	.3857191	-0.71	0.478	-1.029756	.4822349
L2.	-.4139806	.5952774	-0.70	0.487	-1.580703	.7527416
L3.	1.138172	.5778728	1.97	0.049	.005562	2.270782
L4.	-.5802009	.3753746	-1.55	0.122	-1.315922	.1555198
lnInflDiff						
L1.	.2683369	.3695488	0.73	0.468	-.4559655	.9926393
L2.	-.2779267	.6641791	-0.42	0.676	-1.579694	1.02384
L3.	-.2018651	.6698021	-0.30	0.763	-1.514653	1.110923
L4.	.3589483	.3696193	0.97	0.331	-.3654921	1.083389
lnM2Diff						
L1.	1.504212	.37828	3.98	0.000	.762797	2.245627
L2.	.0772756	.5813179	0.13	0.894	-1.062087	1.216638
L3.	-1.092141	.5675178	-1.92	0.054	-2.204456	.0201733
L4.	.5788758	.3698179	1.57	0.118	-.1459541	1.303706
_cons	.0215093	.0095835	2.24	0.025	.0027259	.0402927

Figure 7: VAR model estimates for dataset 2 until February 2020, 215 observations

Equation	Excluded	chi2	df	Prob > chi2
lnEURUSD	lnInflDiff	3.6886	4	0.450
lnEURUSD	lnM2Diff	11.317	4	0.023
lnEURUSD	ALL	21.851	8	0.005
lnInflDiff	lnEURUSD	2.4801	4	0.648
lnInflDiff	lnM2Diff	2.4067	4	0.661
lnInflDiff	ALL	12.057	8	0.149
lnM2Diff	lnEURUSD	10.183	4	0.037
lnM2Diff	lnInflDiff	3.9392	4	0.414
lnM2Diff	ALL	27.788	8	0.001

Figure 8: Granger causality test for dataset 2 until February 2020, Stata output