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The Economics Department and Omicron Delta Epsilon congratulate **Victoria Perez-Zetune**, winner of the 2016 *Dwight D. Eisenhower Society / R.M. Hoffman Family Memorial Prize in Economics*. The Eisenhower/Hoffman Prize is awarded to the economics student writing the best quantitative paper or project with public policy implications.

The Economics Department and Omicron Delta Epsilon congratulate **Victoria Perez-Zetune**, winner of the 2016 *Outstanding Honors Thesis Award*.

The Economics Department and Omicron Delta Epsilon congratulates **Angelica Marra**, winner of the 2016 *Dr. and Mrs. William F. Railing Fellowship for Faculty-Student Research in Economics*.

The Economics Department and Omicron Delta Epsilon congratulate the following students for their achievements in the 2015-16 academic year:

Economics Graduation Banner Carriers:

BA: Michael Russ

BS: Uyen Le

2015 Economics Honors Graduate:

Victoria Perez-Zetune

Omicron Delta Epsilon would also like to thank our outgoing officers, **Marc Franco and Cyndi Greenberg**.

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Impact of a Higher Minimum Wage on Enrollment of SNAP

By Victoria Perez-Zetune

Abstract. This paper investigates the effect that minimum wage policy has on enrollment in public assistance programs, specifically the Supplemental Nutritional Assistance Program, SNAP. If raising the minimum wage decreases enrollment in SNAP, this could uncover a method to reduce spending without eliminating programs. Using a time-demeaned model to account for fixed effects, I take advantage of the variation in the minimum wage in the 50 states between 1998 and 2014. I estimated that on average an increase in minimum wage in a prior year results in a decrease in SNAP participation by 3.95%.

I. Introduction

Since 1939 the Fair Labor Standards Act established minimum wage policy to prevent erosion of consumer buying power by inflation and to ensure fair compensation for labor (Grossman). Proponents of raising the minimum wage argue that it reduces poverty and increases the standard of

living of low-income workers, while the opposition claims it has detrimental impacts on business, increases unemployment, and thus increases poverty. Various studies on the effect of minimum wage on unemployment have found either no impact or a small negative effect (Hoffman 2014; Sabia et al. 2012). An unexplored aspect of the consequences of a higher minimum wage is enrollment in public assistance programs, such as the Supplemental Nutritional Assistance Program, SNAP.

Previously named Food Stamps, SNAP is America's safety net to prevent hunger and improve nutritional intake. In 2012, more than 46 million low-income people were enrolled in SNAP on a monthly basis. A household must be at or below 130% of the poverty level according to federal

guidelines to qualify after deductions for monthly expenses including childcare, medical expenses, and housing (USDA). Evaluations of SNAP conclude that it successfully reduces poverty severity and improves health outcomes, and most full-time workers on minimum wage qualify for at least one public assistance program (Allegretto et al. 2013; Tiehen et al. 2012). The low minimum wage in the United States has a great societal cost. How does an increase in minimum wage affect enrollment in SNAP? Reich and West thus far is the only study to provide causal analysis of the minimum wage and SNAP enrollment, and they found that a 10% minimum wage increase reduces enrollment between 2.4 and 3.2% and overall program expenditure by 1.9% (Reich and West 2015). Establishing the relationship between the

minimum wage and public assistance enrollment contributes to the debate over raising the minimum wage.

The purpose of this paper is to establish further if a relationship between minimum wage and enrollment in SNAP exists. In the following section, I use a time-demeaned model to analyze the question, and the subsequent section will discuss the data collected. Section IV gives the evidence and results, and finally section V is the conclusion with a discussion of the findings and implication.

II. Modeling

Does an increase in minimum wage decrease enrollment in SNAP? Taking advantage of variation in minimum wage laws at a state level, I will examine changes in minimum wage over time and the corresponding impact on enrollment in SNAP.

This would result in a balanced panel dataset, since the construction would be samples from the population over various years with the same units appearing in each time period. If enrollment falls as minimum wage rises, this provides evidence that an increase in minimum wage lowers total enrollment. With panel data, it is necessary to control for time-constant unobserved features that could be correlated with the explanatory variables in the model. A fixed effect transformation eliminates time-constant characteristics specific to individual states, such as geography or more importantly the impact of unobservable cultural attitudes towards public assistance programs that could affect enrollment. As seen below, a model that varies over time and category, state in this case, can be averaged over time for each state. By subtracting

the original model from the averaged, the result is a time-demeaned equation that has eliminated the fixed effect, the unobserved time-constant characteristics denoted by a_i .

$$\text{Original equation: } y_{it} = \beta_1 x_{it} + a_i + \mu_{it}$$

$$\text{Averaged equation over time: } \bar{y} = \beta_1 \bar{x}_i + a_i + \bar{\mu}_i$$

$$\text{Difference: } y_{it} - \bar{y} = \beta_1 (x_{it} - \bar{x}_i) + (a_i - a_i) + (\mu_{it} - \bar{\mu}_i)$$

$$\text{Time-demeaned: } \dot{y}_{it} = \beta_1 \dot{x}_{it} + \dot{\mu}_{it}$$

Using a fixed effect transformation, I am not concerned with variation among states that do not depend on time. If a state has a change in minimum wage, a dummy variable will capture this to see if the impact of the rise in minimum wage had an effect on enrollment that year. I will add a lag of this minimum wage dummy variable because the impacts of policies typically do not have an immediate effect. Other necessary explanatory variables that I must include in my model are

variables that impact enrollment in SNAP that change over time, such as unemployment.

Qualification to participate in SNAP depends on household income and the number of individuals in a household. If unemployment were to rise, household income would fall and enrollment in public assistance programs would increase. Another variable is population growth since a higher population would lead to a greater likelihood for more people to qualify for SNAP. Race and ethnicity should also be included in the model to account for demographic changes over time in different states. Finally, a time variable is necessary to capture changes in enrollment that occur due to time. This would result in the following time-demeaning model:

$$\begin{aligned}
 \log(enrollment_{it}) & \\
 &= \beta_0 + \delta_0 minwage_{it} \\
 &+ \delta_1 minwage_{i\ t-1} + \beta_1 unem_{it} \\
 &+ \beta_2 \log(\Delta pop_{it}) + \beta_3 black_{it} \\
 &+ \beta_4 year + \mu
 \end{aligned}$$

With the time-demeaning variables, an ordinary least squares regression can be estimated. If the estimated coefficient of the minimum wage or the estimated coefficient lag of minimum wage is statistically different from zero, this is evidence that minimum wage policy does affect enrollment in SNAP. If the two estimated coefficients are negative, this would be evidence indicating that a rise in minimum wage causes a decrease in enrollment, holding unemployment, population growth, and the percent of blacks in the state constant. If this were to be the estimated result, the null hypothesis would fail to be rejected, and the fact that minimum wage increases lead to a lower

enrollment in SNAP would be accepted as a causal relationship. Finding this result would further the question if minimum wage changes lower expenditure of public assistance programs due to the decrease in enrollment.

On the contrary, if the estimated coefficient of the minimum wage and the estimated coefficient of its lag are both statistically insignificant, the null would be rejected and lead to the conclusion that increases in the minimum wage result in no impact on enrollment in SNAP assuming that unemployment, population growth, and the percent of blacks in the state are unchanged. Similarly, finding statistical significance but positive coefficient estimates of the minimum wage and the estimated coefficient lag of the minimum wage would also lead to rejection of the null hypothesis

and give evidence that the opposite is true. Positive coefficient estimates would imply that a rise in minimum wage increases enrollment in SNAP.

Using this model is best because the minimum wage and enrollment in SNAP change over time and different states have their own wage legislation. Thus, the relationship between minimum wage policy and enrollment in public assistance programs can be seen both over time and in the different states. With panel data, the standard ordinary least squares regression does not make sense since unobservable, constant characteristics exist that are state specific. When only using two time periods, differencing can be implemented to eliminate such characteristics, but SNAP and minimum wage policy have existed for various years and it is preferable to take advantage of all

available data. Limiting the model to two years could influence the estimated coefficients because it could be a year when enrollment was abnormally high or low due to the time period. Since more than two years are being observed, a time-demeaning model is best.

III. Data

An ideal data set for this model would have information for all years that both minimum wage policy was put into effect and food stamps were created. Minimum wage policy was created in 1938, but food stamps were not a national program until 1974. Furthermore, in 1977 President Carter established eligibility requirements in the Food Stamps Act, so the years of 1974 to 1977 should be grouped to create a dummy variable in order to account for criteria changes in enrollment (USDA

2014). With data spanning 1974 to present day from all 50 states, I would collect the minimum wage of each state annually. SNAP enrollment is given as a monthly estimate, but I would want to know whether or not each person in the United States benefited from SNAP annually. I would want the exact unemployment rate for each state, including discouraged workers who are not measured since unemployment only counts individuals actively seeking a job. Additionally, demographic parameters for each state would be preferred over estimates. I would want to use exact population growth and the racial and ethnic composition of each state. Racial composition would be the actual percentage of African Americans in the state, and ethnic composition would be the actual percentage of Hispanics in the state. Lastly, I ideally would

include average household size because qualification for SNAP is based on income of the household, and a larger household income size has a greater likelihood of qualifying. Average household size could change over time at varying rates in different states.

I was unable to find data spanning all of the desired years; I was limited to 1998 to 2014. The United States Department of Agriculture Food and Nutrition Service provided enrollment in SNAP for each state as the average monthly participation. The U.S. Department of Labor Wage and Hour Division published the minimum wage for each state, excluding farming employment, from 1968 until 2014. The minimum wage was given as a dollar value in normal terms. The Department of Labor also provided estimates for unemployment rate

between 2010 and 2014; prior years were found in statistical abstracts of the Census. Both the population growth and percent of the state population that is black were found in the Census or Current Population Survey. The black population was given as a percent of the total state population, but population growth I calculated by subtracting the current population with the prior years and taking the natural log. Below is a table with a summary of the data collected from 1998 to 2014 and used in the model. I manipulated enrollment of SNAP by taking the natural log in order to interpret the changes as percent changes in enrollment.

Figure 1: Data Summary Table

Variable	Mean	Std Dev	Min	Max
Enrollment	593169.7	683886.5	22485	4349634
Log(enrollment)	12.703	1.159	10.02	15.28
Min Wage	6.09	1.27	1.6	9.32
Min Wage dummy	.3129	.4639	0	1
Min Wage dummy lagged	.3133	.4641	0	1
Unemployment rate	5.818	2.012	2.2	13.5
Log(pop _{growth})	8.99	4.81	-12.438	13.749
Black percent of pop	9.919	9.477	0.177	37.505

The biggest limitation of my data was my inability to find accurate average household size per state and the Hispanic population. Average household size by state was only published for 2000 and 2010. The amount of missing information did not allow me to include this variable in the model. A similar collection issue arose with Hispanic population due to changes in the Census. Major

changes in categories of race and ethnicity occurred in 2008 and 2010 leaving inaccuracy in measurements due to phrasing changes (Cohn 2010). Also, historic data were only collected every decade so I had to begin my data set in 1998 when I would have liked to begin in 1974 with the national Food Stamps Act. Not being able to include the full time range and more importantly two explanatory variables that I believe are significant can cause omitted variable bias.

Another limitation of my data is that as I mentioned unemployment only captures individuals actively seeking a job. Unemployment excludes discouraged workers, people who are not looking for a job due to the belief that there are no jobs available. Furthermore, unemployment measures people who have job searched in the last month and

do not have employment therefore “marginally attached workers” are not considered. “Marginally attached workers” are those who have attempted to find a job in the last year but not the past month (Chapman and Ettlinger 2004). Unemployment does not account for hours worked, so part-time workers who desire full-time positions are uncouned.

Unemployment is a flawed measure in its ability to capture the economic situation of laborers accurately. Furthermore, Census data are collected through questionnaires mailed to households, and self-identification bias could occur for racial and ethnic categories. Also the data collected annually are estimates, not population parameters. Not having the ideal data, all desired variables, and the potential year span limits the validity and accuracy of my study.

IV. Evidence

Implementing a time-demeaning model with an ordinary least squares regression, the following model resulted in the estimation:

$$\begin{aligned} \log(enollment_{it}) &= \beta_0 + \delta_0 minwage_{it} + \delta_1 minwage_{it-1} \\ &\quad + \beta_1 unem_{it} + \beta_2 \log(\Delta pop_{it}) \\ &\quad + \beta_3 black_{it} + \beta_4 year + \mu \end{aligned}$$

Figure 2: Coefficient estimate table

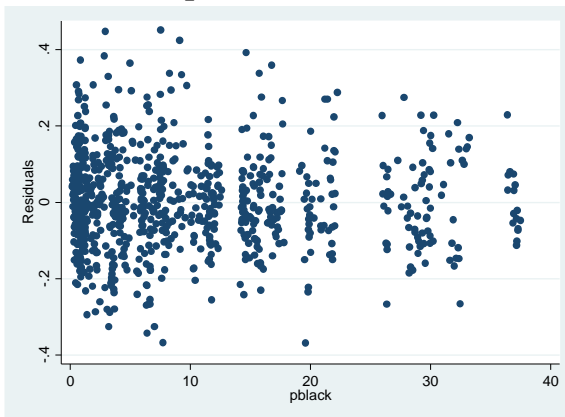
Variable	Coefficient Estimate
Min dummy	-.00794
Min lag dummy*	-.03948
Unem*	.04911
Log(Δ pop)*	.00306
%Black	-.00095
Year*	.05977
Constant	-107.49

* Denotes statistical significance at a 1% level

Surprised by the statistical insignificance of the coefficient estimate of *black* that had a p-value of .485, I plotted the residuals against *black* to

check if there was a pattern in the variance of the error term. When the variance in the error term is not constant, the problem of heteroskedasticity arises. Although heteroskedasticity does not impact the estimated coefficient value, statistical inference is not possible due to inaccurate p-values and t-statistics. The scatterplot below shows the graphical result, and the variance appears to converge.

Figure 3: Scatterplot



In order to correct the standard errors, I ran the regression using robust standard errors. Although

the robust standard errors decreased the p-value on the coefficient estimate of *black*, the coefficient estimate remained statistically insignificant at a 5% level. There were no changes to the statistical significance of any of the estimated coefficients when using robust standard errors.

Given the estimated coefficients, I find that my null hypothesis, that increasing the minimum wage decreases enrollment in the Supplemental Nutritional Assistance Program, is upheld. The coefficient estimate on the dummy variable that equals one when the state experienced a rise in the minimum wage that year is not statistically different from zero, but the lagged dummy variable of the minimum wage has a statistically significant coefficient estimate. The coefficient estimate on the lagged dummy variable of minimum wage has a p-

value of 0; therefore the coefficient estimate is statistically significant at a 99% confidence level. This provides very strong evidence that the minimum wage policy does effect enrollment in SNAP. On average, if in the prior year there is an increase in the minimum wage in a state, enrollment in SNAP decreases by 3.948%, holding unemployment, population growth, and the percent of the black population constant. This shows an increase in minimum wage results in a decrease in enrollment in SNAP, and lower enrollment in public assistance programs signify lower levels of spending without reducing program capacities or decreasing benefits.

The estimated model also found that on average when unemployment rises by one percentage point, enrollment in SNAP increases by

4.91% when other variables in the model are held constant. I expected the coefficient estimate of unemployment to be positive because higher levels of unemployment mean households have lower levels of income, and SNAP enrollment is based on household income. Holding everything included in the model constant, when population growth increases by 1%, enrollment in SNAP increases by 0.306% on average, which is very low in magnitude. Logically, this is also consistent because a larger population means that enrollment will rise due purely to the number of people in the state. Finally, I found that on average as an additional year passes, enrollment in SNAP increases by 5.977% holding other explanatory variables in the model constant.

V. Conclusion

I tested the hypothesis that increasing the minimum wage results in a decrease in enrollment of SNAP. Using panel data from 50 states from 1998 to 2014, I found that an increase in minimum wage in prior years results in an average decrease of SNAP participation by 3.948%. The model used to find this result was a time-demeaned equation with an ordinary least squares regression. Other explanatory variables in the model were the unemployment rate, population growth, the percent of blacks in the state, and time.

This research only begins to uncover causality between minimum wage policy and public assistance programs. Further research could either continue uncovering how the minimum wage impacts the Supplemental Nutritional Assistance

Program by evaluating expenditure or by attempting to find additional data with a larger year span to examine enrollment. Also, there are various public assistance programs that could be tested to attempt to establish causality between spending or participation and the minimum wage. Additionally, I did not evaluate increase in the minimum wage using specific monetary values since I used a dummy variable to capture if a state experienced a different minimum wage. Returning to this project, one could examine marginal impacts of a higher minimum wage.

Investigating the impact of the minimum wage on SNAP enrollment is important because establishing causality could impact our nation's attitude and policy. Furthermore, we could uncover

ways to reduce federal spending while continuing to provide a safety net for the most vulnerable.

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Restructuring the Eurozone

By: Anthony Juliano

ABSTRACT

This paper suggests that there should be a realignment of the current Eurozone. There has been research to argue that the Eurozone does not fit the Optimum Currency Area (OCA) criteria. This might be a contributing factor to the current economic crisis in Europe. I propose, based on results from k-means data clustering, that the Eurozone be divided into three separate regions under the European Central Bank (ECB). The division would allow for enhanced stabilization and efficiency due to better fitting of the OCA criteria and policy implications.

***I would like to acknowledge Professor Charles Wessel for his assistance with the data-clustering segments of this paper and Professor Charles Weise for his overall advisement throughout the construction of this paper.*

I. INTRODUCTION

In 1992, the Treaty on the European Union (TEU) or Maastricht Treaty created the European Union. The treaty outlined five objectives for the Union in the ensuing years. The objective relevant to this paper is the establishment of the economic and monetary union. This paper proposes a division of the current Eurozone into three regional currency areas based on k-means data clustering results for Gross Domestic Product (GDP) growth.

On a large scale, the Economics and Monetary Union (EMU) created interdependence within the member countries, in hopes to prevent conflicts like the first two World Wars in the future. Both Mundell (1961) and McKinnon (1963) indicate benefits to establishing monetary unions or

Optimum Currency Areas (OCA). Mundell (1961) argues that the adoption of a single currency eliminates the problem of domestic currency conversion, as the cost of valuation of foreign currencies, “tend to increase with the number of currencies” (Mundell, 662). In addition, money as a unit of account is less functional, “if the prices of foreign goods are expressed in terms of foreign currency and must then be translated into domestic currency prices” (Mundell, 662). Thus, the conversion of domestic currencies should make exchange between member countries less expensive and more efficient. Building on this idea, McKinnon (1963) discusses the benefits associated with an economy's openness as measured by the size of the tradable sector, the industry sectors whose output in terms of goods or services are

traded internationally, relative to that of the non-tradable sector. In a small and highly open economy, the general price level in domestic currency is sensitive to exchange rate movements. Therefore, monetary unification appears rational, as the economic benefit of a more stable price level would outweigh the economic cost of losing a monetary policy instrument (exchange rate manipulation). At the personal level, each European would also recognize a more efficient system for buying international goods, while the integration of markets, in theory, should create increase labor mobility.

There are also costs to single currency areas. The largest and most significant is the misalignment of member countries' business cycles. This makes the policymaking of the ECB more difficult because

one country may be experiencing a booming economy and another could be in recession. One can currently observe this in Europe today as many of the northern countries are suffering due to the recessions in southern European countries like Spain and Greece.

Several papers have proposed either the creation of a fiscal union or banking union in the Eurozone as a means of fixing the current financial crisis. A fiscal union would allow the Eurozone as a whole to introduce unified fiscal policies in order to stabilize economic issues specific to certain countries. In a different approach, this paper will address the current state of the EMU and propose a solution considering OCA theory. I propose that the current 19 EMU member nations should be rearranged into regional currency areas under one

central bank, the ECB. The first section will discuss OCA theories and the second section will discuss how well the Eurozone fits the OCA criteria. The third section presents my argument for a restructuring of the Eurozone with both my method and results. Finally, in the last section, I will draw conclusions.

II. REVIEW OF OPTIMUM CURRENCY AREA THEORY

In order to evaluate the EMU as a currency area, it is important to understand Mundell's original theory. "An optimum currency area can be defined as the optimal geographical area for a single currency, or for several currencies, whose exchange rates are irrevocably pegged. The single currency, or the pegged currencies, fluctuate jointly vis-à-vis other currencies" (Mongelli, 2). Mundell (1961)

initially suggested a world that was broken into regional currency areas. “If the world can be divided into regions within each of which there is factor mobility and between which there is factor immobility, then each of these regions should have separate currency which fluctuates relative to all other currencies” (Mundell, 663). He claimed that the presence of such a system would then “carry the argument” for the reasoning behind flexible exchange rates. The mobility of factors of production within regions would allow for stabilization process in the event of a demand shift. For example, when the demand shifts from good A to good B, there will be temporary unemployment surrounding the production of good A. Factor mobility would then allow for the unemployed workers to move to good B’s industry, as the

increased demand would require increased supply. Thus, the first criterion for an optimum currency area is the mobility of factors of production, more specifically geographic labor mobility. The second criterion addresses the idea of the symmetry of shocks between countries. The currency area should include countries that tend to experience economic booms and recessions symmetrically, so that the appropriate monetary policies can be assigned for each occasion. The third criterion is the integration of product markets.

Mongelli (2008) provides an extensive analysis of OCA theory from its initial theories to the most current research at the time of the paper. He separates the criterion of the integration of product markets into the degree of economic openness and the diversification of production and

consumption. Economic openness incorporates the degree of trade integration, the share of tradable versus non-tradable goods and services, the marginal propensity to export, and international capital mobility. Production and consumption diversification is essential because it decreases the impact of sectoral shocks to the economy. “More diversified partner countries are more likely to endure small costs from forsaking nominal exchange rate changes amongst them, and to find a single currency more beneficial” (Mongelli, 3). He discusses the tradeoffs of a single currency area, as argued by Tower and Willett (1976). They claimed that the usefulness of money is increased for more open countries, but they compromise the liberty of discretionary macroeconomic policies. Therefore, countries would not have instruments to gain

internal balance during a shock. Mongelli (2008) compares the cost-benefit analysis of previous literature and concludes that price and wage inflation and similarity of shocks are the most important characteristics, with the similarity of shocks acting as a “catch all” property.

A unique aspect of Mongelli (2008) is the presentation of the “new” OCA theory. The first difference between the new and old theory is the cost of dependent macroeconomic policy. The monetarist movement argued that the cost was not as great as the pioneering economists had thought. However, more recent studies now claim that the costs are not as large as the pioneers thought nor as low as the monetarists suggested, but somewhere in between the extremes. Second, there is a creditability problem for countries that have

historically high inflation to claim low and stable future inflation. The solution is having an “anchor” country that has had a proven history of low inflation in the monetary union to legitimize the expectation. The third alteration falls in line with the theory of labor mobility, as it discusses the importance of wage bargaining. Nations that are contemplating a single currency should join with nations that have similarly organized labor markets. “Countries with either strong centralization or strong decentralization are more capable of facing supply shocks than countries with an intermediate degree of centralization” (Mongelli, 13). Finally, the “new” theory discusses the implications of losing nominal exchange rate as an instrument. The classical opinion identified a lag in the manipulation of the exchange rate, which rendered the effects of

the change less effective. However, the more recent opinion, based upon various European devaluations of the 1980s, is that there is a significant cost in losing the ability to manipulate the nominal exchange rate. Thus, it is imperative to partner with nations that have similar symmetry of shocks so that there is a harmonization of policy. The final component involves empirical tests of the criteria, which are similar to the tests run by Eichengreen (1991) and O'Rourke and Taylor (2013) in the next section.

Does Europe fit the criteria?

Eichengreen (1991) offers a critique of whether Europe is an optimum currency area. To do this, he used the variability in the real exchange rates and regional stock price differentials of the European countries to illustrate the symmetry of

shocks between the nations. The variation in real exchange rates represents the lack of symmetry between nations, as nations experiencing booms should have higher relative prices. Thus, if nations were experiencing a boom at the same time, the prices should both be high with little difference between them. Eichengreen tests this criterion by finding the standard deviations of the European real exchange rates for the 1970s and 1980s and compares them to that of the U.S. For the 1970s (see Figure 1), the European standard deviations ranged from 5.4 to 14.0 percent, averaging 8.9 percent, whereas the U.S.'s ranged from 2.0 to 2.7 percent. For the 1980s (see Figure 2), European standard deviations ranged from 1.0 to 9.6 percent, averaging 5.7 percent and the U.S.'s ranged from 1.3 to 1.5 percent. The regional stock price

differentials should also show the symmetry of shocks because, “the profits of equities should reflect the present value of current and expected future profits” (Eichengreen, 6). Therefore, the more closely related the real share prices are across the regions, the more asymmetric the shocks. He evaluates the differentials between the average prices of securities traded on the two regional Canadian stock exchanges (Toronto and Montreal) with differentials between Paris and Dusseldorf. The results show that the stock prices in Canada are historically more correlated than those in Paris and Dusseldorf, therefore region-specific shocks are stronger than in Canada.

Figure 1. 1970s Range of Real Exchange Rate Standard Deviations from Eichengreen (1991)

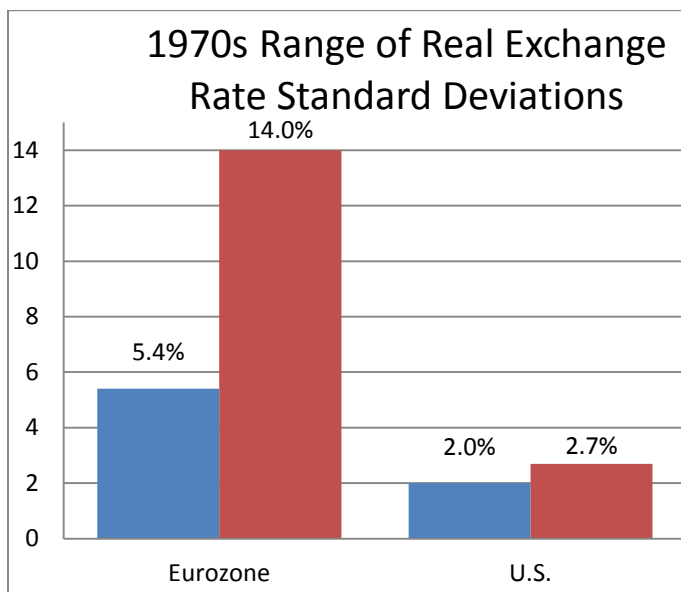
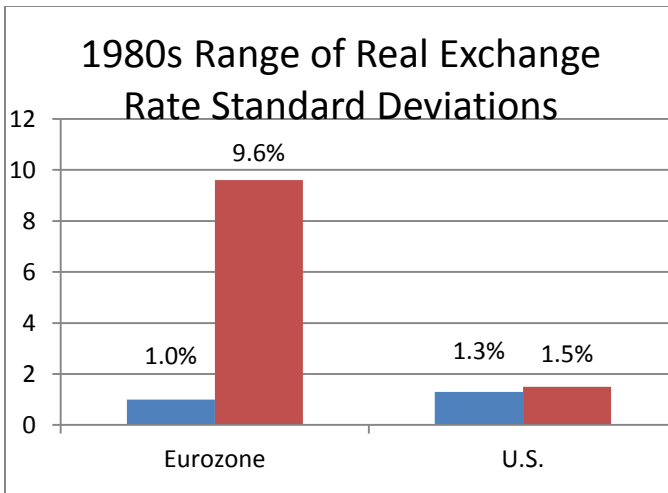


Figure 2. 1980s Range of Real Exchange Rate Standard Deviations from Eichengreen (1991)



Next, Eichengreen (1991) investigates the labor mobility criterion. He bases this section on previous research that made a systematic comparison of the mobility within the U.S. and within the European nation. That study found that the mobility in the U.S. was two to three times as high as mobility within Europe. He also references his own past research in which he estimated regional unemployment differentials for both

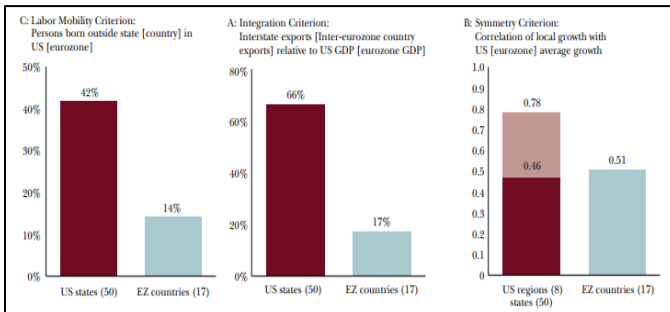
Europe and the U.S. The study found that regional unemployment rates in the U.S. adjust to one another approximately 20 percent faster than national unemployment rates of European countries adjust. While the results clearly show that there is not significant labor mobility between European nations, Eichengreen (1991) does warn of bias due to the presence of international barriers.

In addition to this analysis, O'Rourke and Taylor (2013) also provides data to question the suitability of an OCA for the 17 Eurozone countries (note Latvia and Lithuania adopted the Euro after this paper was published). For the market integration criterion, they compare cross-border interstate trade as a percent of GDP for the U.S. and the Eurozone. They find that cross-border interstate trade was 66 percent of GDP in the U.S. and only

17 percent in the Eurozone. For symmetry of shocks criterion, they considered the correlation between local growth and growth in the monetary union as a whole. The average correlation between real GDP growth in the eight U.S. Census regions and the national real GDP growth was .78 and the average correlation between real GDP growth in the Eurozone countries and real GDP growth across the entire Eurozone was 0.5. Finally, to measure labor mobility, they consider the average amount of people who were born outside of the current U.S. state that they live in compared to the amount of people born outside of the Eurozone country where they currently live. The results were that 42 percent of people in the U.S. were born outside of their current state and only 14 percent of people in the

Eurozone were born outside of their current country.

Figure 3. Results for each criterion from Taylor and O'Rourke (2013)



These results are only a small share of tests that can be used to evaluate the EMU's ability to meet the OCA criteria. Therefore, a more important study would be to identify how the EMU should move forward in correcting the problem of not meeting the OCA, a problem that is somewhat responsible for the current economic crisis. Mundell (1961), Eichengreen (1991), and O'Rourke and

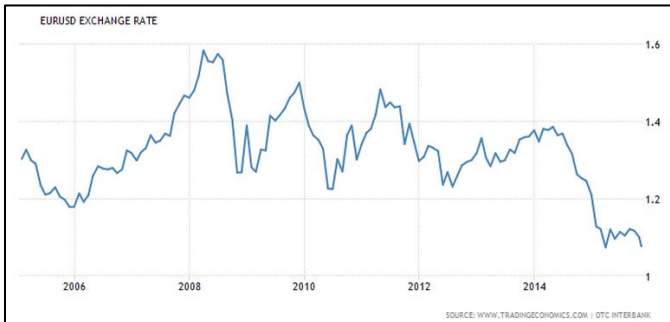
Taylor (2013), along with many more in recent years, suggest that there should be a fiscal union, banking union, or both to support the monetary union that is in place. However, I would like to propose an alternative method to deal with the current economic situation and promote future economic synchronization.

III. RESTRUCTURING THE CURRENT EUROZONE

As I mentioned above, Mundell (1961) initially saw the benefit in dividing the world into optimum currency area regions. I would like to test this theory in the current EMU today because of the following reasons. First, it is apparent from the existing literature that the current 19 independent member nations do not appropriately fit the OCA criteria. Second, a single currency in the Eurozone has proven to be detrimental for both the countries

themselves and the value of the currency, as the Eurodollar has depreciated by approximately 15.9 percent over the last year and drastically over the past five years (see Graph 1). Though one may argue that the depreciated currency has aided the Eurozone economies from worse conditions, I see it as a sign of a weaker economy than it traditionally has been. Third, I believe that the continued existence of a monetary union in Europe is beneficial for maintaining stability on a continent with an abundance of developed economies. In consideration of all three reasons, I argue that there should be a restructuring of the 19 Eurozone nations into regional currency areas that would continue to operate under one central bank, the ECB.

Graph 1. Historical Euro Dollar exchange rate from 2005-2015.



Source: www.tradingeconomics.com | OTC INTERBANK

Regional Currency Areas

Monegelli (2008) provides a blanket statement for the benefits of single currency areas. He argues, “The benefits from a single currency area result principally from the increased usefulness of money, the disappearance of intra-area nominal exchange rate uncertainty that would foster trade and promote cross-area foreign direct investments, and the access to broader and more transparent financial markets” (Mongelli, 5). With that, it may

seem unproductive to separate an already established single currency area. However, Mundell (1961) presents a section specifically pertaining to the theory of regional currencies. He argues an idea that excess demand in one region, experiencing inflationary pressure, could be transferred to the region lacking demand, experiencing unemployment, by allowing regional exchange rates to fluctuate. Therefore, if the EMU continued its policies to maintain price stability and full employment, there might be a stabilization mechanism in optimum currency regions with independent currencies. If one region was experiencing a boom and another a recession, the ECB would allow the booming currency to inflate, while the busting currency would depreciate. This manipulation would have an effect on exchange

rates, so that the demand for goods in the booming region would fall and the goods in the busting region would become more desirable. Therefore, one of the most significant costs of single currency areas, the narrowing of macroeconomic policy instruments, will become less significant with the establishment of three regional currencies. Under this system, the ECB would control the currency and monetary policy for each of the regions, as they will remain in the EMU.

There are some risks associated with this suggestion. Mundell (1961) claims that during, “the gold standard depression in one country would be transmitted, through the foreign-trade multiplier, to foreign countries. Similarly, under common currency, depression in one region would be transmitted to other regions for precisely the same

reasons” (Mundell, 660). This would suggest that the interdependence of the regions on each other could be detrimental if all of the regions fell into depression at the same time. There is also the risk that “fine-tuning” will prove to be ineffective in practice. There are many factors that contribute to the well being of an economy, so the theoretical belief that the regional currencies will promote stabilization mechanisms could fall apart. Overall, the division of the current Eurozone nations into sub-regions under the ECB presents benefits with more proper alignment and potential stabilization instruments, but has certain risk of only being functional in theory.

Method

To further this idea, I use both theoretical and statistical analysis. First, I have considered the

regional currency area theory in Mundell (1961) and Mongelli (2008) by outlining their frameworks in the last section to debate the cost and benefits of having the currency areas, specifically how they respond to shocks in demand. In order to determine the number of regions and the placement of countries for each region, I use the k-means data clustering method. k-means is a widely accepted form of data clustering that finds K clusters by minimizing the distance between each data point and its cluster's center (centroid) using an iterative algorithm that adjusts each centroid's location. With this method, the similar countries clustered around the same centroid will be grouped in the same currency region. My goal is to find three distinct groupings of the Eurozone countries' based on GDP growth rates to illustrate the symmetry of nations'

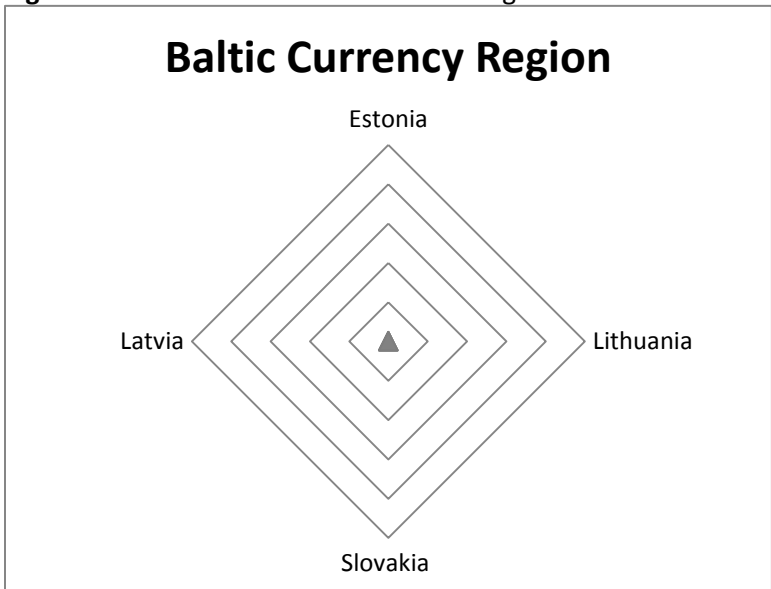
shocks. The GDP growth metric is used in agreement with Mongelli (2008). I will run the k-means in the MATLAB software over 1,000 times in order to find the clusters with the lowest mean distance from the counties to the respective centroids. My dataset includes pre-financial crisis annual GDP data from 2000-2007, extracted from *World Data Bank*. I would prefer to use quarterly GDP data to better observe how the business cycles fluctuated throughout the year for each nation, but am limited to annual data for this paper. In addition to the output from the k-means tests, I will also use geographic location as a determinant.

IV. RESULTS

European Currency Regions

My statistical analysis provided me with three regions for the current Eurozone. The k-means test was run 1,200 times and the sum of the mean distances from country to centroid for each cluster was 243.25. The output provided numerous combinations of mean distances for each cluster. However, the sum of the three clusters was a

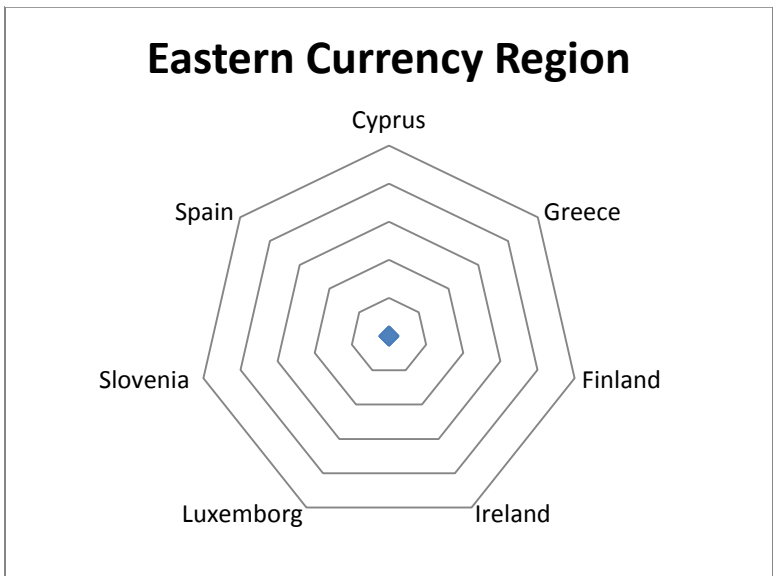
Figure 4. k-means cluster for the Baltic Region



recurring number throughout the tests. Therefore, I used the lowest of the sums, which a combination of the three was 243.25 the majority of the time. The three regions that the k-means results determine are shown Figures 4-6 with the Baltic, Eastern, and Western Currency Regions. The only change that I have made based on location is the addition of Finland to the Baltic Currency Region. Therefore, the Baltic Region includes Estonia, Lithuania, Latvia, Slovakia, and Finland. The Eastern Region includes Spain, Greece, Slovenia, Luxembourg, Cyprus, and Ireland. The Western Region includes France, Portugal, Italy, Germany, Malta, Belgium, The Netherlands, and Austria. While the Baltic Region is logical based on location, the Eastern and Western Region results were more difficult to justify. The Western region consists mostly of the

larger and more disciplined economies, with Germany at the forefront. However, the k-means results further suggest that the economies that continue to experience economic crises are correlated. I believe it may be beneficial for policy making purposes to have a stronger and more stable region in the Western Region and a recovering region in the Eastern region. I will further discuss policy implications of the new currency regions in the next section.

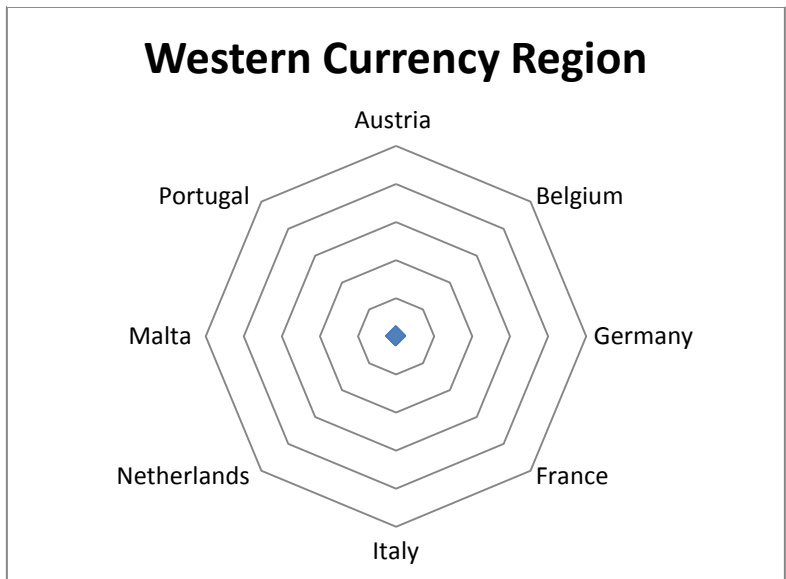
Figure 5. k-means cluster for the Eastern Region



Policy Implications

My recommendation for policy in such a system would be to maintain similar, if not the same targets the ECB has today. The new EMU as a whole would target 2% inflation, but each region could have fluctuating rates in order to enable the stabilization mentioned above. The important question is why I have decided to place one central

Figure 6. k-means clustering for the Western Region



bank in charge of three different currencies. My reasoning is twofold. First, there are distinct reasons why the EMU unified monetary policy in the first place. Second, there is substantial literature that has established the benefits to integrating international policy. Tavlas (2004) addresses the significant creditability that countries that have had recent histories of relatively high inflation rates (Greece, Italy, Portugal, and Spain) gained from eliminating the “inflation-bias problem of discretionary monetary policy” (Tavlas, 94). Those countries were infamous for overstimulating the economies and financing debt and deficits through inflationary measures. Confining the erratic economies to the policies of prudent economies like Germany, with low and stable inflation and inflation expectations, makes each much more creditable and stable. In

consideration of this idea, it would seem foolish to remove policymaking from the one unified central bank due to the risk of potential erratic behavior of countries with previously flawed economic behavior.

In addition, Pikoulakis (1995) devotes a chapter to international monetary policy coordination. He claims that in a multiple country world with rigidities in wages and prices there are negative externalities associated with independent monetary policymaking. By using an example of monetary expansion, Pikoulakis presents how the depreciation of a home currency results in definite “beggar thy neighbor” effects. He concludes by saying the, “absence of international policy coordination leads to contradictory monetary

policies relative to the cooperative outcome”
(Pikoulakis, 185).

In consideration of both of these points, it is logical to delegate the control of each currency to one central bank to ensure appropriate and consistent policymaking behavior along with proper coordination of each regions respective policies.

V. CONCLUSION

One of the main objectives of the Maastricht Treaty in 1992 was to promote the interdependence of European nations by forming a stable and effective economic and monetary union. The current economic situation in Europe is quite the opposite as the troubles of Greece and other southern European nations have caused a significant crisis. The crisis calls for new improvements in order to revive many strong, developed economies.

This paper reiterates the points of Eichengreen (1991) and O'Rourke and Taylor (2013) by agreeing that the current Eurozone is not an optimum currency area by theory. I suggest that the Eurozone could be more stable and efficient if it were divided into three sub-regions. The Baltic Region, the Eastern Region, and the Western Region, would have independent currencies controlled by one central bank in the ECB. The ECB would continue to target inflation as it does today union-wide, while using regional monetary policy as instruments. While this proposal is merely theoretical, further research could make the idea of European currency regions more practical.

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Negative Interest Rates: Analyses Abroad and their
Applicability to the U.S. Economy

By Danielle Cupp

Abstract

The twenty-first century has thus far posed some of the most difficult economic challenges for policy makers that the world has ever seen. The most recent recession, the Global Financial Crisis of 2007-8, is considered the worst economic downturn in recent history. In light of unique challenges such as the recession, central banks around the world are coming up with new tools or new ways of thinking about tools in order to mediate financial crises. This paper investigates the possibility of eliminating the zero lower bound on nominal interest rates to stimulate the economy in reaction to severe financial crises. To substantiate my claim for negative interest rates in times of crises, I challenge the conventional theory regarding the fear of negative interest rates, examine the success of other countries that have employed negative interest rates in order to stimulate economic growth, and provide one example of how potential negative outcomes can be avoided. This paper makes the case that while more research on negative interest rates is to be done, they are a valid option for an economy in crisis and could be used in another circumstance similar to the recession that the U.S. economy faced in 2008-9.

I. Introduction: Interest Rates, Conceptually

The Global Financial Crisis of 2007-8 is said, by scholars, to have been the worst financial downturn the world had seen since the Great Depression of the 1930s. It threatened the collapse of major financial institutions that were only prevented through bailouts, which did not prevent a massive drop in stock prices worldwide. Risk-averse banks withheld from lending to businesses and households. Much of the recession can be characterized as a liquidity crisis, in reaction to which government and central banks resorted to unprecedented fiscal stimulus, monetary policy, and institutional bailouts.

When a central bank cuts interest rates, they are effectively using the tools that they have to

boost an economy that is not faring well.

Decreasing interest rates make investment and consumption more attractive. Additionally, net exports increase and the price of stocks increases.

Raising the interest rate also increases employment and increases the demand for financial assets. In times of economic crisis, the Federal Reserve has historically cut interest rates in order to stimulate the economy in all of the ways that were just listed.

After the financial crisis in 2007-8, not only did the Federal Reserve cut interest rates, but many other central banks around the world reduced their nominal interest rate to 1% or less as well (Ball, 20). The Federal Reserve, though, has neglected to lower interest rates below zero, having constructed a floor on short term nominal interest rate at zero, also referred to as the zero lower bound. In reality,

however, decreasing interest rates have the economic benefits listed above and lowering interest rates further (to below zero) only increases the stimulus to the economy. Conceptually, the difference between a 1% interest rate and a 0% interest rate is the same as that between 0% and -1%. If negative interest rates only further stimulate the economy, why did the Fed not employ them upon one of the worst financial traumas of the past century?

II. Analysis from the Taylor Rule

An analysis on the Taylor Rule provides a more concrete perspective on whether or not negative interest rates should have been implemented after the Global Financial Crisis of 2007-8. The Taylor Rule is a monetary policy

formulae created by John Taylor in 1993 to determine how much the Fed (or other central banks) should change the nominal interest rate in response to changes in inflation and output. The relationship between inflation and the nominal interest rate implies that as inflation rises by one percentage point, the nominal interest rate also rises. My analysis (Graph 1), however, reveals that the Taylor Rule shows that interest rates should have been negative after the start of the Global Financial crisis to one degree or another and that by keeping interest rates above zero after the recession of 2007-8, the Fed deviated from the Taylor Rule.

In order to conduct this analysis, I compared the effective Federal Funds Rate to two different interpretations of the Taylor Rule. In this case, the Taylor Formula was constructed by subtracting

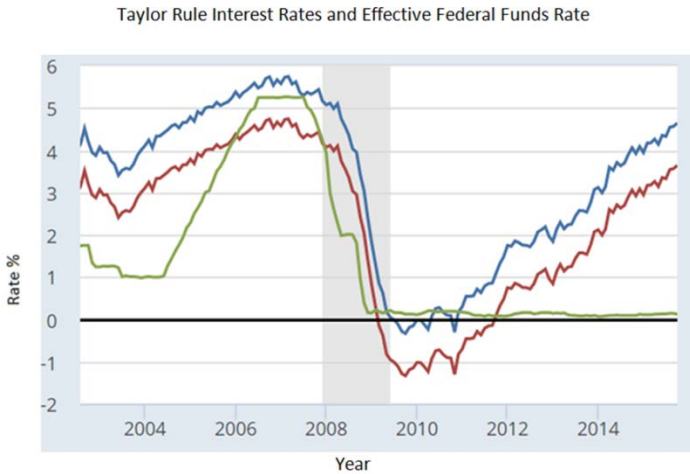
unemployment and personal consumption expenditures from the sum of the natural unemployment rate and the target inflation rate. The graph illustrates that if the Fed had followed the Taylor Rule and the target inflation rate was 2%, the interest rate would have been made negative in July 2009. Minimums as low as -.3, -.34, and -.24 would have been reached in November 2010, October 2009, and April 2010, respectively. The interest rate would have fluctuated back and forth from negative to positive until October of 2010 when they would have remained positive until present.

Some argue, however, that the target inflation rate is lower: 1%. If this is the case, then the projected interest rates as computed by the Taylor Rule would be even lower. According to this formula, negative interest rates should have been

implemented as early as March of 2009 and minimums as low as -1.3, -1.34, and -1.24 would have been reached in November 2010, October 2009, and April 2010, respectively. In addition, a negative Federal Funds rate would have been in effect until October of 2011 while the economy recovered. In actuality, however, between March of 2009 and October of 2011, the effective Federal Funds Rate was an average of .15%. During this time, the rate reached a minimum of .07% and reached a maximum of .21%, but the effective rate was never negative.

Either take on the Taylor Rule shows how there was a need for negative interest rates after the Global Financial Crisis of 2007-8 that were not employed.

Graph 1:

**Legend:**

- Taylor Rule; 2% inflation
- Taylor Rule; 1% inflation
- Effective Federal Funds Rate

Data from Federal Reserve Economic Data (FRED), Federal Reserve Bank of St. Louis

III. False Sense of Flight to Cash

The fears that the Fed has relating to negative interest rates are misplaced conceptually.

Negative interest rates stimulate the economy

because banks are charging their depositors to hold cash reserves while reducing borrowing costs for businesses and households, driving the demand for loans up. Scholars however are concerned that by charging depositors to hold money in their accounts, there would be a ‘flight to cash’. In other words, due to the cost of holding money in accounts, people would prefer to hold their assets as cash instead. I will explore, however, why a decrease in interest rates below zero will not result in a ‘flight to cash’.

First, there are a lot of conveniences associated with having money deposited into accounts rather than holding it in cash that would incentivize depositors to keep their money in their accounts even if they were charged for doing so. Many aspects of society as they relate to finance

revolve around checking accounts. On an individual level, people pay their bills online and pay for their groceries or for a night out with their credit or debit card. For larger purchases, it is even more convenient to pay with a credit card as opposed to cash. To a certain extent, I would argue, people would be willing to keep their own money in an account because it would not be worth the inconvenience to have money *solely* in the form of cash. American society has created many processes in daily life that involve the use of bank accounts. If depositors were charged some fee to keep their money in bank accounts, individuals would be willing to put up with a fee in order to avoid the inconveniences of not having these accounts.

On a larger level, such as a big business, it is also unlikely that corporations would want to also

withdraw their money from their accounts because so many of their processes involve transactions through the banking system. They, for example, pay their customers through basic transactions.

Companies buy out other companies through transactions as well. The idea of a business partaking in either purchasing other companies or paying their employees through cash is almost unimaginable. Again, through the example of businesses, we see how inconvenient it would be for our society to transition from processes involving bank accounts to those of cash. To some extent, businesses would be willing to endure negative interest rates because it is so convenient to make transactions through bank accounts rather than through cash.

Additionally, a 'flight to cash' would not be reasonable considering that holding assets in cash would require some expense in order to keep them safe. Individuals who did not have a lot of money in their accounts (college students for example) might not feel compelled to buy a safe to store their few hundred dollars. Older individuals with life savings of greater magnitude would, rationally, want to buy a safe of some kind to secure their wealth. With more wealth comes a greater incentive (but also a greater cost as safes would need to be larger and therefore more expensive) to secure their wealth. On the level of businesses, again, the prospect that a large corporation would pull out their money into cash and finance some kind of vault and security system just to avoid a charge on keeping their money in an account is almost unimaginable. If

there were negative interest rates, individuals and businesses would be willing to endure a charge to keep their funds in a bank account as long as that charge was less than what it would cost to keep that money safe outside of a bank account.

There must be an interest rate at which either individuals or corporations do decide that it would not be worth it to keep money in accounts and does, in fact, partake in a 'flight to cash', but I suggest, for the reasons relating to convenience and security of assets above, that the zero lower bound does not exist. There is a lower bound on interest rates, but it is less than zero. The degree to which the lower bound is less than zero is unknown and requires further analysis.

IV. Negative Interest Rates in Europe

Negative interest rates have been implemented in countries outside of the United States and did not lead to the flight to cash that economists working at the Fed fear. Negative interest rates were implemented in certain European countries after the most recent financial crisis. An examination of these countries provides further evidence that the lower bound does not exist at zero and that negative interest rates are a viable monetary policy tool should the world see another severe recession.

Sweden was the first nation in this discussion to experiment with negative interest rates. From July 2009 to September 2010, nominal interest rates were cut to $-.25\%$ as a result of the deep recession and having an inflation rate that was persistently below the target rate. Beginning in

2014, the deposit rate was lowered to $-.5\%$ and in February of 2015, the repo rate also became negative, drawing the deposit rate down to -1.1% . It has also announced that it anticipates that the interest rate will remain negative until the end of 2016 at the earliest. Even though depositors at the Riksbank have charged a fee of -1.1% and some government and mortgage bonds, interest rate derivatives, and certificates, have traded at negative rates, the bank has reported that market functioning has been pretty average thus far, with some concerns only in the bond market (Jackson, 11).

Of any central bank in Europe, Denmark has experienced the longest duration of interest rates as well as the lowest interest rate of any country or region under analysis in this paper. In Denmark, interest rates were lowered to $-.2\%$ in July of 2012,

were raised to -0.1% in January of 2013, and only became positive again in April of 2014. This was done to discourage upward capital flows that were placing upward pressure on the krone. The central bank in Denmark, additionally, is one of the few banks to lower interest rates *back* to a negative rate. The central bank of Denmark lowered interest rates to -0.75% in September 2014 again to manage upward pressure on the krone and still has a negative interest rate today. In its most recent assessment, the Danmarks Nationalbank found that negative interest rates did not weaken the pass-through of money to money markets and there have been no significant increases in the demand for cash (Jackson, 8).

The European Central Bank lowered interest rates to -0.1% in June 2014 and again to -0.2% in

September 2014 due to weak economic growth and inflation. The euro area reported “no significant outflows or dislocations in money market funds” (Jackson, 9). Harriet Jackson, an economist at the Bank of Canada, notes that there was some concern in the Eurozone that there would be declines in borrowing from the central bank, but this has not happened (Jackson, 9-10).

As evident by the multiple countries in this study who have implemented negative interest rates in the past decade, there have been no major backlashes to these changes in monetary policy. There has been no indication of a flight to cash by depositors thus far. Jackson, a scholar who advocates for the use of negative interest rates who also draws evidence from these countries in his own analysis, however, warns that the expectations of

negative interest rates may discourage large deposits in the banks (Jackson, 14). Given that negative interest rates are still relatively new, there has not been evidence to indicate that this has happened in economies that have used interest rates, but, again, the longest a central bank has employed negative interest rates without any breaks of positive interest rates was one year and nine months in Denmark. Jackson concludes that while negative interest rates have not been in effect for very long and in many countries, evidence still suggests that they are a viable tool in monetary policy.

V. Gesell Stamp

For those who are convinced that a flight to cash would be within reason should the Federal Reserve decide to experiment with negative interest

rates, there have been economic scholars who have devised creative solutions to eliminate the zero lower bound in a way that the flight to cash is not a risk. The first to do this was Silvio Gesell, a German-Argentine alive during the late nineteenth and early twentieth centuries. He was the first to pioneer the idea of avoiding zero bound traps by paying a negative nominal interest rate on money (Buiter, 725). The possibility of taxing currency has not been realized in history mostly because of the practical difficulties associated with such a feat, but Gesell proposed that in order to provide evidence that negative interest rates, or the tax, had been paid, all cash could be stamped. Decades later, Keynes wrote his own thoughts regarding the complications that a tax on currency would entail. He argued that Gesell was “unaware that money

was not unique in having a liquidity-premium attached to it, but differed only in degree from many other articles, deriving its importance from having a greater liquidity-premium than any other article” (Keynes, 230). In other words, Keynes thought if currency was taxed, people would resort to bartering goods, but he did say that he regarded Gesell’s theory as sound. While there are still costs associated with administering a tax on money, even if a low-cost, tamper-proof high-tech version can be established. For this reason, Buitter brings up the importance of determining the benefits associated with eliminated the zero lower bound and the related costs of taxing currency in order to determine if a stamp-like system is optimal (Buitter, 730). In this way, Buitter is calling for more research to be done so that a central bank can understand the

costs associated with eliminating the lower bound and threats regarding the flight to cash.

VI. Conclusions and Further Research

We have seen how the Federal Reserve has historically respected the zero lower bound and refrained from lowering interest rates into the negative territory despite the worst financial crisis since the Great Depression. Even though cuts in interest rates stimulate the economy and a further cut to a negative interest rate would have only stimulated the economy more, still the Federal Reserve abstained from setting a new precedent of lower interest rates in 2009. Even analysis regarding the Taylor Rule, however, suggests that negative interest rates were appropriate for such a poor economic climate. Negative interest rates have been

avoided in the past because there is fear of a flight to cash, or a situation in which depositors would withdraw their funds from their accounts as keeping their funds in their mattresses would be more profitable than being charged to keep them in accounts. Contrary to this position, much of modern-day society is built around the convenience of modern day banking systems, meaning that keeping all money as cash would be inconvenient, which suggests that people would be willing to pay (to some extent) to keep their money in their accounts. The lack of which the world has seen a flight to cash is evidenced by the fact that multiple European economies have implemented negative interest rates and have not experienced severe occurrences where masses of individuals have withdrawn all of their money from their accounts.

While there have been no major increases in bank withdrawals to suggest that negative interest rates would not be a viable tool for monetary policy, their implementation is still in its infancy with only a handful of countries having experimented with them. The Fed should definitely consider negative interest rates as a future tool for economic crises and should pursue economic research relating to negative interest rates first to explore the unanswered questions relating to negative interest rates before there is an urgent need to use them. There is evidence, for example, that the lower bound does not exist at zero, which then raises the question of where it does exist. In other words, at what point would it not be worth it for people to keep their money in their bank accounts and decide to keep all of their money in cash? How low can

nominal interest rates go? One thing that influences this turning point is people's expectations. If individuals are indifferent about whether or not they should pull all of their money from their bank accounts, but expect that interest rates will rise above zero in the near future, then they will be more inclined to keep their money in their accounts where the opposite is true if they expect that interest rates will stay below zero for a prolonged amount of time. Negative interest rates are a viable option for economies of the twenty-first century even though analysis is still needed to understand the full extent of their implications on an economy.

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**Global Climate Change, Fair Trade, and Coffee
Price Volatility¹**

By Thomas Segerstrom

Abstract:

Fair Trade coffee sales have grown exponentially over the past fifteen years amidst a volatile and shaky coffee commodity market. This paper incorporates the prior research that global climate change will lead to more climate shocks with research on the coffee market's volatility and farmer welfare. In accordance with prior research on commodity volatility, I develop an OLS estimator of the volatility of prices received by growers and evaluate the effect of climate shocks on it. I find that, when control variables are introduced, the volatility of the coffee price does increase at a statistically significant level with a climate shock. I evaluate the claim made by the

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Fair Trade movement that their program is a way to mitigate climate change, and I incorporate qualitative research that confirms the concerns observed in relation to climate change and farmer welfare.

I. Introduction

There is overwhelming consensus among climate scientists that the earth's temperature is increasing and becoming more unpredictable (IPCC 2014). Some climate scientists have suggested that agriculture over the past thirty years has been subject to more yield variability, and thus indirect changes in prices. This increased variance in temperature can also lead to higher volatility in commodity markets (Brown and Gibson 2006). Coffee growers are one group of commodity producers who are particularly affected by price volatility, and it appears to be negatively affecting their wellbeing (Mohan et al. 2014). In this paper, I

investigate the relationship between global climate change, particularly changes in temperature and climate shocks, and commodity price volatility in the coffee market. In addition, I will examine, theoretically, whether Fair Trade contracts, which offer pre-negotiated prices to growers in exchange for more sustainable agricultural practices, can mitigate some of the negative effects of commodity price volatility for coffee producers.

Why is this important, economically? In theory, many individuals will have to adapt to changing climate conditions, and many more will be unable to adapt. This research is aimed at understanding climate-related price fluctuations and shocks in the coffee market, and examining to what extent voluntary Fair Trade initiatives could improve the welfare of farmers and help them adapt

to greater uncertainty. Nevertheless, it is vital to the research since reducing the vulnerability to volatility is one of the primary goals of Fair Trade.

Existing statistical studies suggest that climate change has had a negative effect on crop yields and production (Lobell et al. 2010). Discussion on the concept of Fair Trade and climate change has focused on remarkably very few studies that have suggested a link between climate shocks and more volatility (Roache 2010, Brunner 2002). Prior literature has also incorporated climate simulation models to suggest that global climate change will create more price volatility and lead to considerable welfare losses for millions of people (Tran et al. 2012). Rather than rely on climate models or specific individual cases, this project uses data on coffee markets, and temperature variations

to empirically measure the effects of climate change on prices and thus farmer welfare (via price volatility).

To begin, I model price volatility as the primary connection between climate change and farmer welfare; that is, climate change affects farmers because it leads to increased price volatility. There is prior evidence that, in general, persistent price volatility hurts farmers (Mohan et al. 2014). I incorporate the shock of significant climate events into a regression of price volatility.

Results in this paper indicate that climate changes do have a significant impact on the volatility of coffee prices. In addition to my quantitative analysis, I also incorporate a deeper perspective on climate change by presenting the

results of the interviews I had with small-agriculture producers. This paper also presents areas for further research into volatility clustering in coffee prices.

II. Literature Review

Commodity markets are, by nature, very volatile and prices change often. This effect is easily noticeable since the liberalization of many commodity markets (rice, sugar, oil, coffee, etc.) near the end of the twentieth century (Cashin and McDermott, 2002) and even since then. The economic history of many of coffee-producing economies indicates why this is the case. Many coffee-producing countries were formerly Western-controlled colonies and are still emerging as developing economies. Thus, much of the coffee

production since the end of colonial times in many countries has been subject to various export-import schemes, market regulations, and region-wide protectionist policies. However, since the end of the International Coffee Agreement in 1989, the coffee market has largely been subject to the forces of globalization and the free market, angering some.

One “consequence” of the free market on commodity farmers has been that prices swing often at the whim of market forces and buyers. The phenomenon of commodity price volatility has been investigated in previous papers that suggest that volatility is a problematic element for farmer welfare. Cashin et al. (2001) examine the length and magnitude of price booms and slumps, coffee included, and determined that coffee prices endure more price swings, volatility, and longer periods of

lower prices than other commodities. Additionally, Cashin and McDermott (2002) conclude that short-run movements in commodity prices are highly unpredictable, and price volatility has been increasing in magnitude since the 1970s. Moledina et al. (2004) analyze multiple commodities and seek to answer whether there are any welfare gains from less volatility. They argue that eliminating price volatility very little welfare gain.

No study has focused on climate change on the coffee market. Older studies have found links between climate shocks like the El-Niño Southern Oscillation Index (Brunner 2002, Frechette and Delavan 1998). More recent studies indicate projected changes in the coffee “suitability”, or ability of Arabica coffee to grow in pre-existing coffee regions (Ovalle-Rivera 2015). With

potential changes in supply due to climate change, coffee prices and volatility will change too. Tran et al. (2012) use complex climate simulations of multiple commodities to predict that changes in global temperatures in the coming years will lead to more price volatility leading to a welfare loss for millions of people. This news can seem rather alarming, so it is imperative that the relationship between climate changes and coffee prices be investigated empirically to see what negative welfare effects it has had on farmers.

Preliminary estimates by Bacon (2005) and Dragasanu and Nunn (2014) show that Fair Trade farmers do in fact receive slightly higher prices than non-Fair Trade farmers. As Mohan (2010) argues, Fair Trade can only establish long-term benefit for farmers if revenues, in contrast to price increases,

can be stabilized. Volatility is important, nevertheless, and much of the prior literature suggests that it is a variable of interest in econometric analysis of farmer welfare.

This research paper incorporates these previous observations about the climate and market. It relates these concepts via estimation of volatility using standard deviation as authors have previously conducted using various standard control variables also used in prior findings. With these estimations, this paper contributes statistical findings on volatility of coffee market that were previously only measured on other commodities.

III. Theory

Volatility indicates how much a price varies from previous prices. Volatility also measures an

inherent risk, financially, that exists when farmers must make seasonal production and investment decisions. The more variation from previous values, the more of a welfare decrease for farmers, so to speak. Farmers do not welcome volatility, in theory, because of the wider range of expected returns on crops. Thus, increased volatility and farmer welfare have a negative relationship with each other because farmers have a more difficult time making production decisions as predicting future prices is more challenging.

Consistent with Roache (2010), in this paper I examine the determinants of volatility by running a standard ordinary least squares (OLS) regression. Within this OLS regression, I measure climate volatility in several ways, the effects of frost and drought by introducing dummy variables.

Theoretically, a frost or drought will reduce market supply and increase the coffee price. Since farmers cannot prepare very adequately for a frost or drought occurrence as crops are outdoors and the climate effects are out of their control, if frosts and droughts do occur more frequently with global climate change, this higher level of volatility will lead to a decrease in their welfare. Volatility in this context is measured by the rolling standard deviation of the monthly log price difference: $d = \ln(p_t) - \ln(p_{t-1})$. This method to measuring volatility is adopted by several commodity-related studies (Mohan et al. 2014, Roache 2010). I also introduce several control variables in the regression that account for other world market changes that could explain increased volatility, just as Roache (2010) does. Thus, the regression model looks like:

$$(1) \quad \sigma(d) = B_0 + weathervariable_i + real_i + dusgdp_i + \sigma(\pi)_i + \sigma(3mo)_i + \sigma(\varepsilon)_i$$

Within, *real* represents the real inflation rate for a particular country, *dusgdp* represents the first difference of USGDP, a commodity-literature measure for demand changes, the level and standard deviation of the US inflation rate, the standard deviation of the US risk-free rate, and the standard deviation of the US exchange rate. This modeling takes into account changes in world demand, measured broadly via USGDP, and other factors that might influence the volatility of coffee prices to growers identified by Roache (2010).

IV. Data

The prices included in this paper are from the International Coffee Organization (ICO) and

represent nominal monthly prices to growers in a panel of Arabica coffee producing nations from the period 1980-2013. Prices are quoted in US cents/lb, and to derive a real price series, the prices are deflated using a UN “unit value index” obtained from the International Monetary Fund to keep consistent with Mohan et al. (2010). This is done to keep measurement of prices consistent over time in real terms. Monthly prices are also obtained from the IMF for index commodity prices.

Weather data is taken from publicly available data from the US National Oceanographic and Atmospheric Administration (NOAA) and is shown on the website’s map. Weather dummy variables (0 or 1) used to indicate frost, or drought in a given month are derived from coffeeresearch.org. Weather data about the

standard deviation of maximum temperature is taken from a weather station in Belo Horizonte, Brazil, a popular coffee-producing region in Brazil and combined with the coffeeresearch.org information. Brazil has a very large market share of global Arabica coffee production, and many changes in coffee news, and prices are centered around Brazilian coffee production and climate. While the data as a whole are from a panel for price changes, the very large effect of Brazilian climate shocks has a noticeable effect in the news and changes in prices traded in financial markets are directly observed as a result. Unfortunately, panel data on frosts and droughts cannot be completely traced and relied upon in NOAA data available as many weather archive reports from developing countries are incomplete. However, the data from

Brazil and the website do work well with the other data.

V. Results

The results of estimating equation (1) yields some very interesting results about volatility. Using the regression model testing weather variables, the standard deviation of the grower price of coffee to producers in a panel of countries, and other important covariates, the results indicate that frost and drought have an immediate impact on coffee prices and volatility. Additionally, the results indicate that it is not directly higher temperatures, commonly thought of with climate change, that lead to higher volatility levels, but rather shocks to the climate via droughts and frosts. These weather events, which are thought to increase in the future with climate change, are crucial to understanding

why coffee prices are volatile. Regression results are described in Table 1, below.

Within the table, regression (1) tests the standard deviation of the maximum temperature of the Brazil location. The coefficient on this term (0.00023) is not statistically significant at any level, while other covariates are – this supports the understanding that higher temperatures are not directly relevant to coffee price volatility. Rather, regression (2) tests, in Latin American countries and South America, whether climate shock weather changes such as drought and frost, which can kill crops and eliminate much of a farmer's income. This term is statistically significant and positive (0.03717), meaning that on average, the standard deviation of the monthly log difference of prices received by growers increases. Practically, this

means that the expected returns of the coffee price differs more with a higher coefficient. With more spread-out expected returns, coffee farmers' welfare is decreased.

The term is also lagged to account for changes that occur in the month before that will affect farmers and their expected returns. A similar regression (3) introduces a frost lag with the covariates and is statistically significant at the 5% level. This coefficient is also positive (0.23180), meaning that volatility increases with a frost (lagged for the same reason). These results support the belief, generally given by the farmers that I have interviewed and environmental economic researchers, that frosts and droughts are incredibly serious and affect volatility even when introduced with other explanatory variables for volatility.

While the R-squared values of these regressions are rather low, the low value is to be expected of time

Dependent Variable:	St. Dev. Of Grower Price
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series, fixed effects regressions.

Table 1 - Measuring Volatility of Grower Prices

Variable:	(1)	(2)	(3)
Inflation	-0.00864	-0.00332	-0.003667
Level	(0.00197)***	(0.001539)**	(0.001196)***
Real Interest	0.0023	0.00386	0.002036
Rate	(0.00097)*	(0.000811)***	(0.000622)***
dUSGDP	-0.00006	-0.0001	-0.000026
	(0.000028)**	(0.00002)***	(0.0000178)
Inflation	-0.03586	-0.04075	-0.030799
Volatility	(0.008221)***	(0.006413)***	(0.00497)***
Exchange	-1.7736	-0.00205	-1.01318
Rate Vol.	(0.4642)***	(0.004301)	(0.30070)***
SDMaxTemp	0.00023	-	-
Lag	(0.000197)		
Frost Lag	-	-	0.23180
			(0.007854)**
Frost or	-	0.03717	-
Drought Lag		(0.00739)***	
Constant	0.1715	0.1356	0.14396
	(0.103)***	(0.00833)***	(0.00647)***
Fixed	Yes	Yes	Yes
Effects?			
R-Squared	0.031	0.031	0.020
N	4370	4854	9935

*,**,*** indicate significance at the 10%, 5%, 1% levels respectively.

VI. Qualitative Effects

Qualitative research is a key aspect of market coffee research, and Fair Trade. Research into the coffee market on the societal effects and opinions of those directly affected is often pushed to the wayside, even though it can reveal much of what cannot be quantified. To get a taste of what

was out there, I decided to get ahold of some agricultural producers in Adams County, PA that I knew I could get ahold of.

Through a publication on agriculture and Adams county farming and tips from a college at Gettysburg College, I was able to get in contact with a Honduran farmer named Emilo Garcia, living in central PA. Garcia and the other Adams county participants interviewed mentioned that price volatility is an important production concern. Additionally, frost and drought were concerning and a contemporary issue to all subjects interviewed. These results confirm that climate change is indeed a serious issue addressing coffee farmers. Furthermore, with research indicating that “suitability” of coffee farms becoming more difficult (Ovalle-Rivera 2015), as coffee must be

cultivated in a very specific climate that is, as of now, rapidly changing, more volatility may be expected.

VII. Analysis of Regression Data and Further Research

While the quantitative results are significant, they could be subject to some unforeseen complications. It is possible that in evaluating volatility, the regressions omit key variables that have not been accounted for that might implicate the regression to misestimate the effects of frost and/or drought. This would lead to a misestimating of the coefficients. Measurement error, whether it be through how frost data and weather data are collected or how grower prices are gathered, is also a very likely problem that could occur in the regression results. It is possible that Brazil is not

necessarily the only determinant for large-scale price fluctuations and volatility for coffee farmers due to frost and drought. While these climate-related events may happen elsewhere, Brazil still has such a large market share that it can capture many of these effects.

One area for future research would be to introduce a study of volatility clustering. Volatility clustering implies that periods of high volatility are often followed by other periods of high volatility and vice versa, is often noticeable in financial markets (Engle 1982). In this paper, I account for volatility clustering by introducing a generalized autoregressive conditionally heteroskedastic model (GARCH model) used by many economists to account for this phenomenon. The GARCH model, which analyzes what goes into monthly log price

changes and takes account for the error variance of the model $var(u_t) = h_t$. Thus:

$$(2) p_t = B_0 + B_1 p_{t-1} + B_2 X_{t-1} + u_t$$

$$(3) h_t = \alpha_0 + \alpha_1 u_{t-1} + \phi_1 h_{t-1} + \dots$$

where p represents the monthly log price difference and all coefficients are unknown. The error variance of the equation is modeled because the variance of the term can be estimated as a function of the previous period's variance, thus implying conditional heteroskedasticity. Conditional heteroskedasticity means that the variance of our price, over time, can be related to a function of the time-period it is in. For example, p_t is a function of p_{t-1} . In this paper, I develop prices to be a function of the monthly log price difference, as seen with Mohan et al. (2014) but where I introduce control

variables into the regression to account for other factors that might influence price changes. (eqns 3,4)(4)

$$\ln(p_t) - \ln(p_{t-1}) = d_t = B_0 + B_1 d_{t-1} + B_2 \text{controls} + u_t$$

$$(5) \quad h_t = \alpha_0 + \alpha_1 u_{t-1} + \phi_1 h_{t-1} + \text{controls}$$

Within this set of regression equations, equation (5) is measuring the variance of the error term in (4). This set of regressions would estimate the effect of climate shocks on the price changes in coffee, and also estimates the effect of heteroskedasticity in the data.

VIII. The Contribution of Fair Trade

Much of this paper has been dedicated to exploring the theme of climate change and its effect on the coffee market. It is noticeable in the coffee

market that farmers are susceptible to price volatility. The Fair Trade movement has made a claim about climate change that is quite notable and well intentioned. The Fairtrade Foundation, a major Fair Trade non-governmental organization (NGO) states on its website:

Given the lack of fairness found within the conventional trading system, consumers support farmers so they can receive a fair price by buying Fairtrade products. Farmers are paid an amount that aims to cover the costs of sustainable production, which allows them to do future business projections. This is especially important in times of instability and volatility, as prices can significantly fluctuate. (Fairtrade Foundation)

This quotation beckons a discussion of what is exactly “fair”. After a careful review of the literature surrounding Fair Trade, it does not appear that the can do much about the price volatility effects due to climate shocks. Fair Trade lacks a mechanism to mitigate the price volatility found from the effects of climate change.

Fair Trade NGOs often only discuss prices in policy position papers, pamphlets, and other sources. The biggest fallacy with discussing only “fair” prices is that farmers only care about prices, instead of income. Simplistically, income for a farmer is price multiplied by quantity. Mohan (2010) observes that “producers are not concerned with price per se, but price is important to them to the extent that it affects their income”. While it is documented that Fair Trade producers do get earn

higher incomes according to many studies (Bacon 2004, Reynolds 2009 and others), Fair Trade cannot completely insulate farmers from price volatility caused by global climate change and other factors. Dragasanu and Nunn (2014) also note that even with Fair Trade coffee, no farmer actually sells his entire crop as Fair Trade.

In fact, price volatility will probably get worse in the coming years with increased variability in the climate. While the efforts by Fair Trade are laudable when it comes to sustainability, all coffee farmers are still going to be subject to price volatility unless the Fair Trade movement creates a strong system of income assurances.

IX. Conclusions

Overall I find that climate change does

indeed affect the coffee market. Global climate change, via droughts and frosts leads to higher price volatility for coffee farmers. The data seem to indicate this trend This statistically significant trend is noticeable in coffee prices to growers, and supports prior research suggesting that global climate change will affect commodity producers via droughts and frosts. With increased droughts and frosts, there is an increased variability of expected returns for coffee farmers, and uncertainty.

Fair Trade proponents are keen to notice this relationship between global climate change and coffee price volatility, and it is supported through the interviews conducted in Adams County with Emilio Garcia and others. Further research into the topic of coffee price volatility would include an investigation between the persistence and

conditional heteroskedasticity of coffee price fluctuations. While Fair Trade seems to have a lot going for it on the charitable side, there is not theoretical justification for it preventing volatility or insulating farmers from climate related price swings.

There are many policy implications to the results of this study. Agricultural scientists have been warning about the potential changes awaiting the production of coffee. This research confirms suspicions that droughts and frosts have affected volatility. Thus, volatility is just a catalyst for lower farmer welfare as a result of climate change. If Fair Trade, as a movement, truly wants to mitigate climate change, it would require fundamental changes to its models of supporting farmers to ensure income stability. Nevertheless, if

Fair Trade coffee is a product that people want, they should go ahead and buy it – they just should be more weary of its ambitious public statements.

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