Vol. I
2014

THE DEVELOPING ECONOMIST

An Undergraduate Journal of Economics

THE UNIVERSITY OF TEXAS AT AUSTIN™

The Developing Economist

An Undergraduate Journal of Economics
The University of Texas at Austin
Volume 1

2014

The Developing Economist

An Undergraduate Journal of Economics

It was a great honor and privilege to serve as a founding member and the first editor-in-chief of *The Developing Economist*. Were it not for the patience, effort, and dedication of those that I was fortunate enough to work with, this project would have been far more arduous a task to complete.

I'd like to especially thank Robert McDowall, President of UT's Omicron Delta Epsilon chapter, for his unending steadiness and motivation; Jana Cole, Academic Advising Coordinator, for her generosity with both time and resources; Christina Kent, Managing Editor, for her discipline and off-the-cuff brilliance; and Sarang Joshi, Editor and right-hand man, for his friendship and always-appreciated collaborative support. Further thanks must be extended to our team of editors: Daniel Champan, Tianran Chen, Ruzseth Anne Dela Cruz, Leonardo Gonzalez, Shreyas Krishnan Shrikanth, Garrett Lay, and Malay Patel; for their service and willingness to take this journey with me.

Also appreciated was the counsel of Dr. Kendrick, Dr. Linden, Dr. Trejo, Dr. Glover, and Carlos Parra.

This journal was founded during the semester that two of our founders (and great friends) graduated. Alan Lujan and Affonso Reis had a vision that our publication would serve as a showcase for high-quality undergraduate work from scholars around the country, hoping to offer a substantial contribution to the world of economic research. I hope to have fulfilled my part of this mission in presenting the six articles selected for the 2013-2014 edition here, and offer my highest hopes for the future. After I've left the University of Texas at Austin, I have faith that my successors will see the value in what this team has done, and will continue the legacy we leave with the zeal and enthusiasm that such an endeavor requires.

Carl Marvin Gustafson
Editor-in-Chief
The Developing Economist

On the Cover

Pictured on the cover of *The Developing Economist* is the University of Texas tower, a beacon of majesty and academic excellence. It houses important administrative offices, including the Office of the President, a library, and an observation deck which offers some of the most breathtaking views of the UT campus and Austin.

The Guild of Carillonneurs play the Knicker Carillon atop the tower during special occasions such as "Gone to Texas", an official freshmen welcome ceremony. Generally illuminated in white, the tower dons a majestic burnt orange color in celebration of special occasions such as athletic victories and academic accomplishments. Affectionately dubbed the 'UT Skyscraper', the University of Texas tower is an image carried in the memory of every Longhorn.

Cover Design: Leonardo Gonzalez

Photo Credit: Shreyas Krishnan Shrikanth

A Note From the Chairman

We extend great thanks to the University of Texas at Austin, the Department of Economics, the College of Liberal Arts, and The International Economics Honor Society of Omicron Delta Epsilon. Without your unwavering support completion of this project would not have been possible.

I would like to first congratulate our outstanding editorial staff and leadership team, including ODE officers Mario Peña and Erin Roper. Their dedication and hard work brought this project to completion. We hope that *The Developing Economist* will continue to act as a venue for the publication of undergraduate research for years to come.

In addition to the members of faculty that assisted in reviewing those papers selected for publication, I would like to thank Dr. Abrevaya, Dr. Oettinger, and Dr. Bencivenga for their support of ODE and undergraduate research at the University of Texas.

We received many great research submissions, and choosing just a handful of papers for publication proved difficult. Those published herein truly represent undergraduate research of the highest quality.

I extend congratulations to those researchers featured, and wish them the best in all future endeavors.

Robert McDowall
President
Omicron Delta Epsilon
The University of Texas at Austin

Staff

Carl Marvin Gustafson
Editor-in-Chief

Robert McDowall
Chairman

Garrett Lay
Operations

Editorial

Christina Kent
Managing Editor

Daniel Chapman

Sarang Joshi

Shreyas Krishnan Shrikanth

Malay Patel

Design

Tianran Chen

Ruzseth Anne Dela Cruz

Leonardo Gonzalez

Contents

Efficient Pricing of Carbon in the EU and its Effect on Consumers

Michael Lee

Abstract

A European single market for electricity is modeled to find the optimal portfolio of energy generation technologies in the presence of a carbon tax. The goal is to find the Pareto optimal carbon tax rate such that both carbon emissions and production costs are minimized. Different sources of electricity– namely coal, natural gas, nuclear, wind, offshore wind, and solar– are given levelized costs and carbon dioxide emissions (CO_2) on a per megawatt-hour (MWh) basis. 20,000 energy portfolios, each with different allocations of the respective generation techniques, are generated via a Monte Carlo process and subsequently evaluated by their per MWh cost and emissions. The cost of each generation technology is related to the upfront capital expense, the variable operations and resource costs (O&M), the amount of CO_2 it produces and the EU-wide carbon tax rate. This tax-rate is increased until the most cost-efficient portfolio is also the least CO_2 producing– thus finding the optimal carbon tax-rate for aligning environmental and economic interests. **Data extracted from this model suggests that this efficient price is around $80 USD per ton of** CO_2

The effective production price per MWh from the simulation is then compared to the average industrial power price for each of the EU-member states in order to evaluate the effect of an EU-wide carbon tax on end-users. **The optimal portfolio recommended by the simulation, in conjunction with transport via a Pan-European SuperGrid, will be able to supply power at a similar (**$\pm 5\%$**) price to the current EU 27 average while dramatically reducing greenhouse gas emissions.**

I. The Problem with Carbon

Over the past 100 years the global temperature has risen 1.53 °F. However, since ocean temperature tends to rise slower than land, the overall effect is more pronounced for Earth's landmasses.

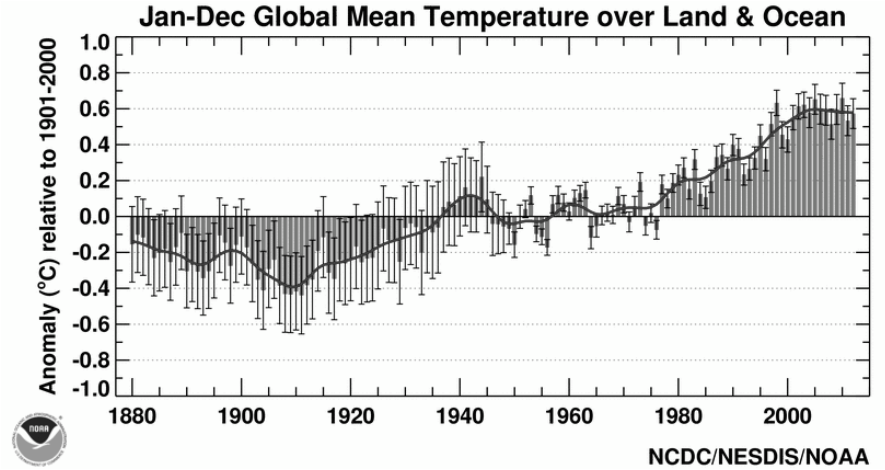

Figure 1: Rise in Global Temperatures Since 1880 (NOAA, 2011)

While there are those who contest the science, the vast majority of climatologists attribute this sustained rise in global temperatures to the increased use of fossil fuels for transportation and power. In the US, the largest source of these CO_2 emissions come from the generation of electric power followed by transportation. While no similar data could be found for the EU, Europe's lower car-utilization rate suggests that its percentage of CO_2 emissions from electric generation is higher than that of the US (global average from electric generation is roughly $\frac{1}{3}$).

Clearly, if the EU, and the world, are serious about reducing greenhouse gas emissions, we will have to make changes to the way we generate electric power.

Carbon in the EU's Political Landscape

Currently there is no EU-wide carbon tax. In the 1990's a carbon tax was proposed to the EU Parliament, but this measure failed. However, in 2005 the EU began its emissions trading scheme (EU ETS), commonly referred to as "cap and trade". Under the EU ETS a maximum allowance of greenhouse gases (GHG) is set for each of the 11,000 plants under the regulation. If the operator emits more than its allotted amount of carbon, it is forced to buy carbon permits from other users on the market, thus constraining the aggregate emissions level (European Commission, 2013).

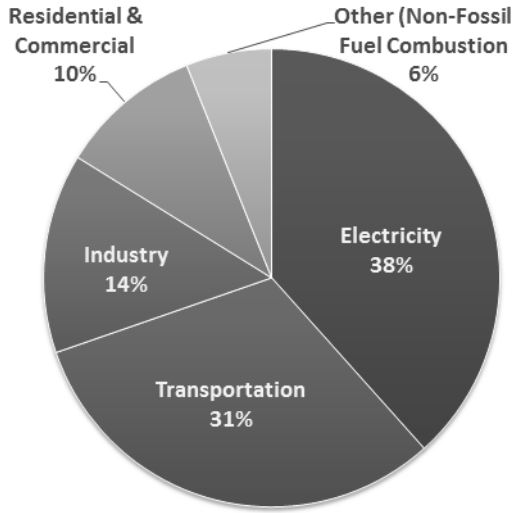

Figure 2: Breakdown of Greenhouse Gas Emissions by Source (EPA, 2013)

Carbon in the EU's Political Landscape

Opponents of carbon taxation argue that it is a regressive tax, since it will disproportionally hurt lower-income households. A tax on carbon would cause production costs of electricity to rise, a cost that would ultimately be passed on to the consumer. Assuming all users are charged the same rate for power, the rate increase would represent a larger share of lower-income families income. Additionally, more affluent families are able to afford the upfront capital expenditure associated with buying new, energy efficient appliances, LEED Certified homes, home solar panels, etc. while poorer household will remain reliant on electricity-produced from burning fossil fuels.

Cap and Trade vs. Carbon Tax

Theoretically, both the Cap and Trade and a carbon taxation scheme will achieve the same outcome of reducing GHG emissions, however in practice they behave quite differently.

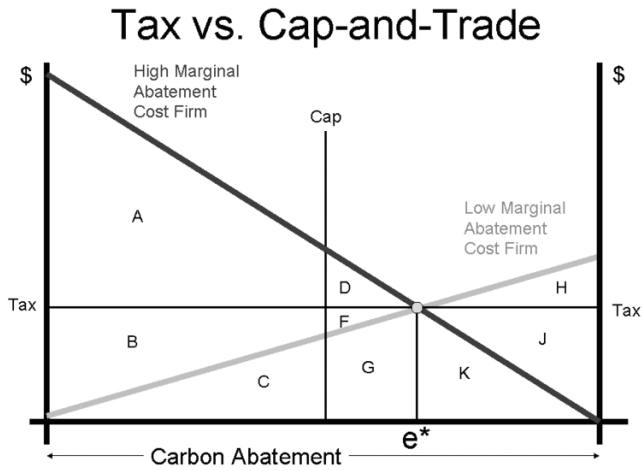

Figure 3: Carbon Tax vs. Cap and Trade (Environmental Economics)

In the EU, all existing power stations were issued a base carbon allowance for free, essentially making the scheme free for them as long as they maintained current emissions levels. On the other hand, a carbon tax will impose immediate costs on all emitters as each unit of carbon has a price. This helps explain why this program was able to pass the ballot while taxation was not (Taschini, 2013).

Carbon taxation is more difficult to implement because the price at which it is taxed at is extremely important– too low and industry might just pay the tax and continue emitting GHG, too high and consumers suffer dramatically higher prices. **It is this pricing problem that this paper centers on.**

II. Carbon from Electricity

In addition to being the largest single source of greenhouse gases, electric generation is amongst the low-hanging fruit when it comes to reducing global emissions. Chiefly this is because:

- The scale of power plants means switching one plant from coal to gas will have a large impact
- Power plants are designed to last 20+ years, helping capital recovery for a 'green' investment

- Technology is already in place for reduced or zero emission sources
- Even if personal transports shifts towards electric vehicles, electric generation will need to be cleaner

Electric power demand is predicted to increase in Europe as more and more tasks traditionally fulfilled via internal combustion (IC) or natural gas (e.g. transport and home heating) become electric. This in-and-of itself is good– large-scale electric generation is much cleaner and energy efficient than IC, however this will force governments and utility companies to build new generation stations. New power plant construction in-turn raises the question of what *type* of power plants the EU should invest in.

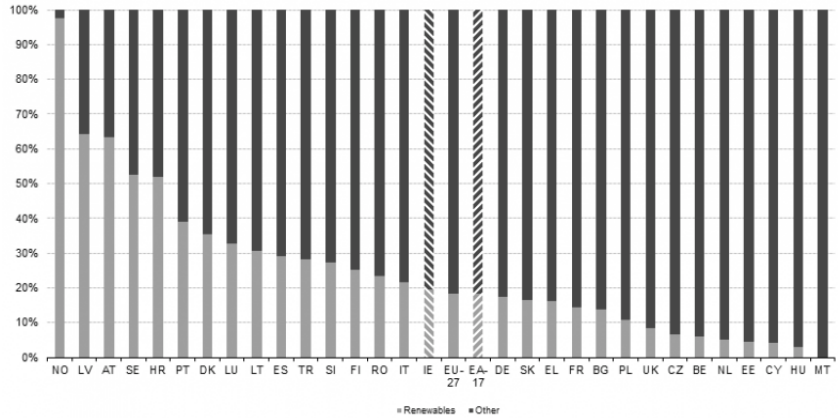

Figure 4: Share of Renewables in Electricity Production (Eurostat, 2012)

The Current State of Power Generation in Europe

Europe varies greatly when it comes to the methods used to generate electricity. Norway, produces over 90% of their power from renewable sources, while others such as Malta produce almost 0% of their power using renewables. Overall, the EU 27 stands at about 18% generation from renewables. Between 1990 and 2008, the share of electricity produced from renewable sources increased by 288 TWh, an increase of 87.2% (European Environmental Agency, 2011).

As seen in **Figure 4** for the vast majority of European nations, electric power is produced primarily by conventional thermal, i.e. burning a fuel to produce heat. Traditionally this has meant coal and oil,

but increasingly the world has shifted towards nuclear and natural gas as its main heat sources. As we will see, the various methods of producing this heat have dramatically different environmental impacts.

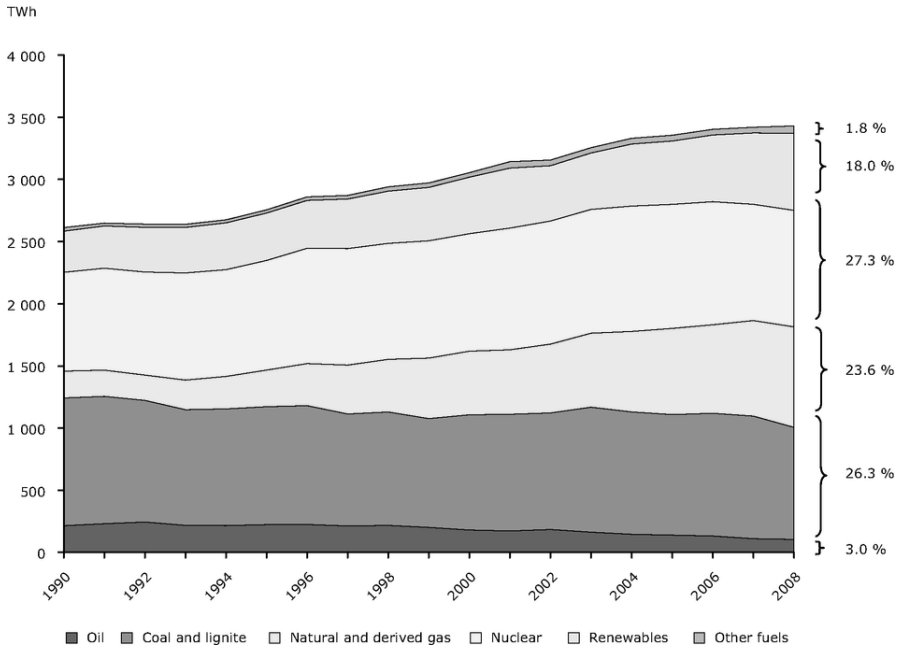

Figure 5: Electric Generation by Fuel Source (Eurostat, 2012)

Methods of Generating Electricity

All types of electric generation[1] are derived from the same fundamental principle: Faraday's Law. Faraday's Law states that a voltage is induced by a change in the magnetic environment of a coil. Electric generators operate on this principle: 1) magnets are placed along a rotating shaft 2) this shaft is placed inside to a coil of wires 3) the shaft is connected to a source of rotary motion (turbine, engine, etc.) 4) the spinning of the shaft causes a change in the magnetic field and 5) an electric voltage is produced. Fossil fuels enter the equation to provide the rotary motion. In the most general sense, some heat source (usually combustion) causes a pressure increase in steam which in turn

[1]With the exception of fuel cells and photovoltaic which rely directly to the flow of electrons

causes a fan blade to spin. Renewable sources sidestep the combustion process and, in the case of hydroelectric and wind, use the fluid flow to turn the fan blade, or the thermal energy of the sun to heat water as in the case of solar thermal.[2]

As mentioned earlier, the type of fuel used as the heat source dramatically effects the output of CO_2 and other pollutants (NO_x) per MWh. Renewable sources produce zero GHG emissions, while coal and natural gas produce CO_2 as a byproduct of combustion. The relative emissions are shown below:

Coal (anthracite)	228.6
Coal (bituminous)	205.7
Coal (lignite)	215.4
Coal (subbituminous)	214.3
Diesel fuel & heating oil	161.3
Gasoline	157.2
Propane	139
Natural gas	117

Figure 6: Pounds of CO2 Emitted per Million BTU (US Energy Information Administration, 2013)

As seen above, natural gas produces about 57% less CO_2 than bituminous coal (the most commonly used for electricity generation). Thus, it follows that replacing all existing coal power plants with natural gas would reduce GHG emissions by over half!

Perhaps a more striking difference than the relative CO_2 emissions is the cost difference between sources. When discussing the cost per MWh, we must first establish the different factors internal to the pricing:

- Capital costs
- Fixed operations and management
- Variable operations and management (fuel)
- Transmission investment
- Capacity factor

[2]It is important to make the distinction between solar thermal and solar photovoltaic. The former uses solar radiation to heat a working fluid while the later exploits a property of certain materials that causes them to shift polarity when heated

The first four costs are self-explanatory, but the last is a bit subtle. The capacity factor[3] (CF) is the percent of time that the source will run– a measure of intermittence. For example, if a 1 MW turbine produced 3000h MW over the course of a year, it would have a capacity factor of 34%. Thus, a 100 MW solar installment (CF=.25) could not reliably provide as much power as a 100 MW gas turbine (CF=.87). More formally:

$$Capacity\ Factor = \frac{Actual\ Produced}{Nominal\ Capacity} \tag{1}$$

Capacity factors have large implications on the optimal energy portfolio since a certain base load of power will be needed at all times. This suggests that a global optima of cost and emissions exists since a grid comprised completely of renewables would require a nominal capacity of three times the actual requirement– a three-fold cost increase. **This paper aims to find the Pareto optimal combination of cheap, reliable, polluting thermals with expensive, intermittent, and clean renewables.**

Another important distinction is that between *Dispatchable* and *Non-Dispatchable*. Dispatchable technologies are those that can be switched on and off, as well as being able to ramp up or down production based on demand. Dispatchable technologies are more valuable to grid operators because they allow them the flexibility to meet the variable loads demanded throughout the day.[4]

Dispatchable Technologies	Cap. Factor	Capital Cost	Fixed O&M	Variable O&M	Transmission	Total Cost
Conventional Coal	85	65.7	4.1	29.2	1.2	100.1
Advanced Nuclear	90	83	11.6	12.3	1.1	108.4
Conventional Combined Cycle	87	15.8	1.7	48.4	1.2	67.1
Non-Dispatchable Technologies						
Wind	34	70.3	13.1	0	3.2	86.6
Wind-Offshore	37	193.4	22.4	0	5.7	221.5
Solar PV	25	130.4	9.9	0	4	144.3
Hydro	52	78.1	4.1	6.1	2	90.3

Figure 7: Levelized Costs For Various Generation Technologies (US Energy Information Administration, 2013)

[3]Readers familiar with electro-mechanics will recognize this as the duty cycle

[4]While technically coal and nuclear are dispatchable, they are more traditionally used to supply base loads since they take more time (days) to ramp up. Aero-derivative gas turbines are the ultimate dispatchable because their production can be started and stopped in a matter of hours.

Grid Considerations

The intermittent supply of solar and wind power raises concerns about the stability of the grid. This intermittency, coupled with the unequal demand, could cause blackouts if supply was at a low while demand was at a high (around 4pm). Conversely, if there is not enough demand to meet the supply, blackouts could be caused by wind turbines overloading the transmission lines. Transmission lines, like highways, are limited by their capacity, and large surges of energy can cause them to overload and shutdown, which can potentially cause nationwide voltage drop and subsequent blackout (Cardwell, 2013).

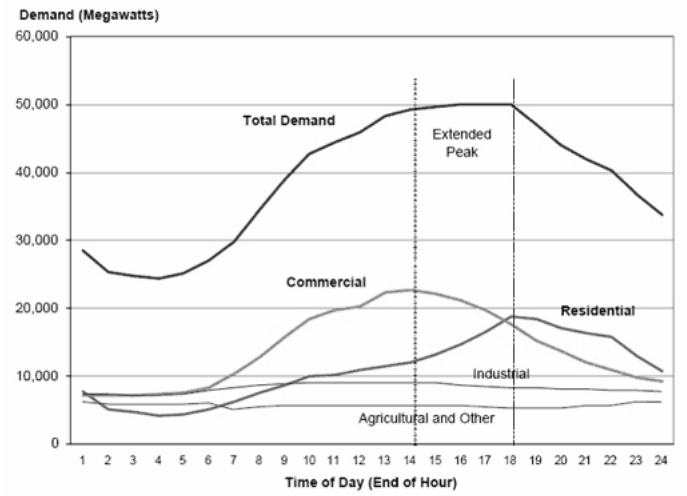

Figure 8: A Typical Load Profile (Lawrence Berkeley National Laboratory, 2005)

A typical grid operator will want a base load, supplied by nuclear, coal, or natural gas, of around 50% of peak demand. This way, when the wind blows or the sun shines; there is still a demand node for the generated power to go to. However, since these renewable sources are intermittent, utility companies specify a certain percentage of dispatchable reserves (DR), which can be turned on, should there not be adequate renewable generation to satisfy demand. Gas turbine engines ordinarily generate these reserves. Usually, this reserve ratio is around 70%.

$$DR = Percent\ Generated\ from\ Renewables \cdot Reserve\ Ratio \quad (2)$$

Once again, we will see how the intermittent nature of renewable generation technologies effects the optimal energy portfolio as the cost of building a wind or solar installation must also include a the cost of a fractional dispatchable installation.

European Super Grid

One of the proposed methods for avoiding the variability of wind and solar resources– other than using conventional dispatchable reserves– is to have a more integrated grid, where power could be transported anywhere in Europe for reasonable electrical losses. This would help smooth out the variability of wind speeds in a specific region[5]. The main obstacle to this is the construction of new high voltage direct current (HVDC) lines across the continent. However, this could conceivably be achieved in a decade (Claverton, 2009).

III. Computational Model

To evaluate the efficacy of the carbon tax on the utilization rates of multiple generation technologies, a computation model was created. The model uses a Monte Carlo process in conjunction with a statistical tool known as the Dirichlet distribution to randomly create an array of portfolios, each with a different share of the various generation technologies. These energy portfolios were then evaluated based on their cost and CO_2 emissions. Certain thresholds were placed on all portfolios to ensure that they were plausible in the real world, namely that a percentage of power was generated from dispatchables (§2.3).

Monte Carlo Simulation

Monte Carlo simulations are often used in modeling in situations where a closed-form analytic solution is not readily available or exceedingly computationally intensive. A Monte Carlo simulation relies on repeated random sampling of input variables to obtain an optimal result. In the case of portfolio management (whether it be energy or equities), by randomly choosing the asset allocation percentages and

[5]Often cited as "its always windy somewhere"

calculating the costs repeatedly, the law of averages states that as the number of simulations approaches infinity, an optimal solution will be found.

Dirichlet Distribution

In the proposed model, sampling was done according to the Dirichlet distribution, which ensures that some number of points in a set, n, are randomly sampled such that their sum is equal to some specified total. Thus, the Dirichlet distribution has the statistically appealing property of being the conjugate prior to the parameters of the multinomial distribution. In the computational model, the distribution generates N values, bounded by [0,1] that sum to unity.

$$p(\mathbf{p}) = Dirichlet(\mathbf{p}, \mathbf{u}) = \frac{1}{Z(\mathbf{u})} \Pi p_i^{u_i - 1} \tag{3}$$

Dispatchable Reserve Rate

As mentioned in §2.2, grid operators maintain a reserve of dispatchable capactiy based on the fraction of total capacity generated from renewables. Since this is an *a posteriori* calculation after the desired supply from renewables has been decided, it is calculated in the same manner in the model.

The Dirichlet distribution first creates a portfolio consisting of the generation technologies listed in **Figure 7**[6] where the sum of the weights equals 1. Afterwards, an algorithm adds the requisite percentage of dispatchable reserves to the portfolio.[7] For reserve requirement λ:

for i in portfolio **do**
$Portfolio^i_{Dispatchable\ Reserve} = \lambda(Portfolio_{Wind} + Portfolio_{Offshore\ Wind} + Portfolio_{Solar})$
end for

[6] Coal, Nuclear, Natural Gas, Wind, Offshore Wind, Solar, and Hydroelectric

[7] This means that the nominal capacity of the grid is always greater than 100% supply

Qualification Criteria

Over 20,000 portfolios were generated and stored in a matrix. However, many of these did not meet certain the base load requirement, and were removed. With the remaining portfolios, matrix operations were performed to calculate the cost and emissions. The portfolios that had the highest and lowest cost and CO_2 emissions were then kept for each tax rate.

*Base Load If energy portfolios did not meet a predefined percentage of power generation from dispatchables (ρ), they were culled from the dataset.

if $w_{coal} + w_{gas} + w_{nuclear} < \rho$ **then**
  $delete\ portfolio$
else
  $keep\ portfolio$
end if

All subsequent qualifications (cost and emissions) are done to include the addition of dispatchable reserves to the portfolio.

*Hydroelectric Power Since the amount of power generated from hydroelectric sources is fixed by the number of damable rivers, a limit is placed on the percentage of power that can come from such sources. Research shows that this limit is around 15% of total electric demand.

if $w_{hydro} < 15\%$ **then**
  $delete\ portfolio$
else
  $keep\ portfolio$
end if

*Emissions Emissions for each portfolio were calculated by using the weighted average of each generation technology and its respective CO_2 emissions (as described in **Figure 7**). Where ϵ_i is the CO_2 emissions per MWh of generation technology i, $w_i^{portfolio_n}$ is the weight of generation technology i in $portfolio_n$, and $CO_2^{portfolio_n}$ is the total CO_2 emissions for portfolio n per MWh.

$$CO_2^{portfolio_n} = \Sigma\, w_i^{portfolio_n} \cdot \epsilon_i \tag{4}$$

Costs The costs of each portfolio are tied to the rate at which carbon is taxed and the levelized cost per MWh of each generation technology. Thus, if the portfolio produced more carbon, it would cost more

than one that produces less *ceteris parabus* This is stated mathematically as:

$$cost^n = w_i^n \cdot cost_i + (\tau \cdot CO2^n) \tag{5}$$

Where $cost^n$ is the cost of portfolio n and τ is the effective carbon tax rate per tonne of CO_2.

The tax rate τ was systematically increased and cost recalculated for the same 20,000 portfolios until **the portfolio with the minimum cost was the portfolio that had the lowest emissions.** This tax rate represents the socially optimal tax rate of §1.1.1.

IV. Results

The model yielded a final result that matches well with our intuition of what an 'optimal' energy portfolio would look like: nuclear in the place of coal, a diverse mix of renewables, especially hydroelectric[8], and supplemental gas turbines for peak demand.

It is my belief that wind power is underrepresented in this model because of its intermittency. If a power grid similar to that explained in §2.3.1 is implemented, the capacity factor of wind on a super national level could theoretically be as high as 80% (Airtricity, 2013)[9]. If the model takes into account this new capacity factor, wind would surely be the dominant resource in the portfolio, as suggested by Gregor Czish in his study of the Supergrid (Claverton Energy, 2009)

It is also important to note that these allocations provided do not take into consideration factors such as geopolitical risk of relying on an extra-national energy supply. The study is also run assuming free market conditions with no government subsidies for nor investment price floors for generated power[10]. Perhaps most importantly, the model does not take into consideration the *existing energy mix* of the EU. Thus, the relative cost of building new nuclear plants would be higher than using the existing gas turbines and simply paying the tax.

[8]Hydroelectric is highly represented because it is has a relatively high capacity factor and is semi-dispatchable. While the maximum output is limited by the flux of water, it can be adjusted down from this maximum by gearing the connection between fan and generator shaft.

[9]The Airtricity proposal is heavily weighted towards offshore wind generation which bypasses some of the NIMBY-ism that plagues wind turbine construction

[10]Definitely not the case for the EU. In the UK the government has guaranteed that power generated from renewable sources a price of 87 PS per MW, compared to the market price of around 47 PS

In this regard, the model is to be seen as a target for an optimal energy mix of the EU as a whole, not as a blueprint for bolt-on construction.

Optimal Carbon Pricing

The optimal carbon price is defined as the tax rate at which the cost of of producing carbon is equal to the price of using a renewable source. Thus, the optimal carbon tax rate (τ) is found when the portfolio with the lowest cost first becomes the same as the portfolio with the lowest emissions. **By this definition, the optimal tax rate is $80 USD per ton of carbon.** Past $80, there is a deadweight loss as no more social benefits are produced in the form of cleaner air yet the cost of production– and therefor consumer prices– increases.

With Carbon Tax = $80				
	Min C02	Max CO2	Min Cost	Max Cost
gas	0.99%	2.72%	0.99%	0.06%
nuclear	77.29%	1.00%	77.29%	0.95%
coal	0.47%	83.06%	0.47%	71.05%
hydro	8.55%	3.17%	8.55%	1.36%
wind	3.13%	4.47%	3.13%	2.25%
solar	8.05%	3.37%	8.05%	3.16%
offshore wind	1.52%	2.22%	1.52%	21.17%
dispatch res.	8.89%	7.04%	8.89%	18.61%
sum	108.89%	107.04%	108.89%	118.61%
percent carbon prod.	10.35%	92.82%	10.35%	89.72%
cost	$121.11	$202.31	$121.11	$224.14
CO2	108.88	1871.01	108.88	1695.74

Figure 9: The Optimal Carbon Tax Rate

As seen above, the optimal mixture is heavily weighted towards nuclear and hydroelectric power. Confirming out intuition of what would constitute a 'dirty' portfolio, the most polluting portfolio uses coal as its primary energy source (83%). In the spirit of the taxation, at a tax rate $80, the most expensive portfolio is also heavily weighted towards coal (71%).

The Effect of Renewables on Consumer Utility Prices

For measures such as the European Supergrid to pass, ultimately the voters will have to approve measures that will raise their taxes. In

today's economic climate this will prove difficult, it not impossible, unless consumers can be shown that they will benefit in the medium to long term in the form of lower utility prices. Currently, the average price for electricity in the industrial sector[11] in the nations studied is around 97 Euros per MWh (Europe's Energy Portal, 2013). Converted to US dollars at current exchange rates, this price is around $132 per MWh.

Including an average profit margin for utility providers of 3% (Yahoo! Finance, 2013), the cost of the portfolio suggested by this model is $125 per MWh. With a margin of error of plus or minus 5%, these results imply that a Europe with reduced emissions can be achieve at a similar, if not lower, price than currently facing households. The data produced by this model is confirmed by the research of Gregor Czish (Claverton Energy, 2009) If cleaner air won't motivate consumers, surely this will.

V. Future Improvements

This model will be expanded in the future to consider the location of the power plants suggested by this model. Population dynamic considerations such as population density and population growth will motivate the location of power plants, as will physical factors such as line losses from HVDC transport and local distributive capacity.

The future model will also take into consideration the existing mixture of energy resources currently in place in Europe to provide a guideline for which type of power generation the EU should invest in– and in which order– to achieve maximum reduction in emissions at the minimum cost. *

References

[1] EIA. "How Much Carbon Dioxide (CO2) Is Produced hen Different Fuels Are Burned?"" *U.S Energy Information Administration*. U.S Energy Information Administration, n.d. Web. 9 Dec.2013.

[2] Habb, Tim, and John Whitehead. "Econ 101: Carbon Tax vs. Cap-and-Trade." *Environmental Economics*. N.p., n.d. Web. 9 Dec. 2013.

[3] Tashini, Luca, Simon Dietz, and Naomi Hicks. "Carbon Tax v Cap-and-Trade: Which Is Better?" *The Guardian*. N.p., n.d. Web. 9 Dec. 2013.

[11] Industry was used instead of household since it more closely follows the cost of electric production for utility companies. Since the data modeled is based on *production*, this was deemed prudent.

[4] European Commission. "The EU Emissions Trading System." *Europa*. European Commission, n.d. Web. 9 Dec. 2013.

[5] PBS. "Sources of World's CO2 Emissions." *Frontline*. Public Broadcasting Station, n.d. Web. 9 Dec. 2013.

[6] EPA. "Overview of Greenhouse Gasses." *EPA*. United States Environmental Protection Agecy, n.d. Web. 9 Dec. 2013.

[7] UCAR. "How Much Has the Global Temperature Risen in the Last 100 Years?" *University Corporation for Atmospheric Research*. UCAR, n.d. Web. 9 Dec. 2013.

[8] Plumer, Brad. "What Happens if You Add Lots of Wind and Solar Power to the Grid?" *The Washington Post*. The Washington Post, n.d. Web. 9 Dec. 2013.

[9] Wind Energy Center. "Wind Power: Capacity Factor, Intermittency, and What Happens When the Wind Doesn't Blow?" *Wind Energy Center*. University of Massachusetts Amherst, n.d. Web. 9 Dec. 2013.

[10] Puka, Lidi, and Kacper Szuleki. "Plans to Create a Pan-European Electricity Grid as Part of the Common Energy Market Face a Number of Challenges Before They Can be Realised." *London School of Economics*. LSE, n.d. Web. 9 Dec. 2013.

[11] Andrews, Dave. "Why Do We Need The Supergrid, What Is Its Scope And What Will It Achieve?" *Claverton Energy*. Claverton Energy, 9 June 2009. Web. 9 Dec. 2013.

The Implausibility of the Barter Narrative & Credit Money in Ancient Babylon

R. D. Baker[1]

Abstract

Whereas the standard economics textbook literature motivates the emergence of money by pointing to the inefficiencies of barter economies, there is virtually no historical evidence that this is how money actually came about. Due to the lack of evidence for the existence of barter economies, an attempt is made therefore to hypothesize an origin of money which is more compatible with the organization of early societies. This alternative story is explained with the help of a model of four trading merchants, in which barter is shown to be dominated by credit simply on the basis of bargaining power and the ability of a centralized middleman to complete transactions between agents. This simple model represents the ability of individuals and institutions in establishing units of account. The organization of economic transactions around lines of credit is supported with historical evidence and is found in one of history's earliest civilizations. The codification of the loan contract in ancient Babylon, when combined with the historical evidence and simple thought experiments about the viability of credit, demonstrates that credit systems are a more historically viable starting place for the emergence of money than barter.

I. Introduction

The usual textbook account of the emergence of money in human societies treats money as the solution that arose to address the inefficiencies of barter economies. This narrative has a long history spanning over two millenia – the story has been speculated upon by Aristotle, was made explicit by writers like Adam Smith, is even used as an acceptable starting point for modern papers on the topic, and finally is suggested as the correct explanation in the thought experiments of modern economics textbooks. There are a few major problems with this narrative however:

[1]The author would like to thank Prof. Andrew Glover for his guidance and advice, and the University of Texas at Austin for providing the opportunity to do this research.

1. There is a lack of evidence to suggest that many societies were organized around barter in the way that the narrative requires.

2. There is wealth of evidence that prehistoric societies and early historic economies (e.g. Egypt and Babylon) used credit and centralized redistribution as the primary modes of allocating resources.

3. Credit-based economies are more efficient than barter-based economies on purely theoretical terms when trading partners know each other and currency either does not exist (as is the case when it has not been "invented" yet), or is in low supply. This suggests that a primitive economy would be better off borrowing or operating as a gift economy.

To evaluate each of these objections in a sensible way it is important to define the terms and outline the barter narrative these objections are meant to refute. To begin, let's start with money and how it came to be according to this story.

II. Money as defined in the barter narrative

In textbook discussions and in the general literature, money is most often defined functionally [2] as that which is [3]:

1. a Medium of Exchange;

2. a Unit of Account; and

3. a Store of Value.

These functions convey that 'money is what money does', a notion used due to the complicated history of what we would colloquially refer to as money. In the modern literature a wide variety of definitions for money exist, and while ten of the prominent definitions have been catalogued (Osborne, 1984), the functional definition is both the definition used in the barter narrative and one sufficient to highlight a major flaw in the economic literature that exists today. Of the three functions listed above, one reasonable question might be 'which is the

[2] after Hicks (Hicks, 1967).

[3] There are many other definitions of money, but the three-function definition is the most common found in macroeconomics textbooks. In the twentieth century many economic thinkers have defined money in different terms.

most important feature of money?' or 'which is the most essential?'. Depending on the perspective, and especially depending on the time and place in history, there are reasonable arguments to be made for each of these functions being the dominant or quintessential function of money.

In the literature however, the barter narrative overemphasizes the role of the medium of exchange function to the point at which it distorts our view of how economies actually operated. In early societies like ancient Babylon, the monies of the day (standardized weights of silver and barley) were used primarily as units of account and a means of payment on debt.

The word 'barter' is sometimes used loosely to mean any form of exchange of goods and services without the use of money, but that is not how the word is used in the barter narrative. In the barter story, traders confine themselves to transactions in which goods and services are exchanged simultaneously among willing participants. Thus there are no mechanisms for credit or gifting between two trading partners, and the practical methods of theft and swindling are ignored. This restricted form of trading is how the word 'barter' is traditionally used in textbooks.

The barter narrative as implicit in textbook discussions of money

Textbooks often justify the existence of money, alluding to the barter narrative, by introducing the *double coincidence of wants* problem. That is, if two agents wish to trade they must both have something the other wants. Because the two agents are unlikely to be able to match up their wants with what they actually have to trade, they are not likely to find a good trade to make. A recent textbook example illustrates this point, invoking the double coincidence problem and arguing that money solves it with the medium of exchange function:

> "The use of money as a medium of exchange permits trade to be accomplished despite a noncoincidence of wants... ...Suppose that Nebraska has no interest in Florida's oranges but wants potatoes from Idaho, [Idaho wants some of Florida's oranges but none of Nebraska's wheat, and] Florida wants some of Nebraska's wheat but none of Idaho's potatoes. We summarize the situation in figure 2.1. In none of the cases in the figure is there a coincidence of

> wants. Trade by barter clearly would be difficult. Instead people in each state use money, which is simply a convenient social invention to facilitate exchanges of goods and services. Historically, people have used cattle, cigarettes, shells, stones, pieces of metal, and many other commodities, with varying degrees of success, as money." - McConnell, 2012

This is a convincing argument that if money were to suddenly vanish in the modern economy, money would solve many of the inefficiencies caused by the lack of it. While this is a good point to make to students of the modern economy, it does not address the origins of money but rather illustrates a likely origin of our misconceptions. We are told to consider an economy organized around trade with money, and then asked to *imagine* how hard it would be for such trades to continue without it. It is important to emphasize that this particular phenomenon of money reemerging has occurred in history. For instance, Cigarettes (mentioned by McConnell et al in the above quote) were used in POW camps in the second world war as currency by prisoners familiar with the concept of money as a medium of exchange (Radford, 1945).

Thus economists are faced with a problem – every writer on the emergence of money writes from a perspective of having witnessed money in a modern form. Thus, in order to understand the origins of money beyond the confines of conjecture, it is necessary to examine what less modern societies actually did with their resources. But even when this is done, care must taken to not connect the dots. Modern money is only one of many ingredients in modern economies, and so it is not necessarily true that money, as we are familiar with it, emerged in an economy with strong divisions of labor or in one with notions of private property. History shows that nature of money does not remain constant in all its varied social and economic contexts even if it satisfies the three-function definition. The emphasis on one function may not always be clear or insightful, since what we call money has traditionally satisfied all three. The textbook rendition of the barter narrative thus poses a serious threat to the value of the three function definition, because it argues effectively that the only function that really matters is the medium of exchange function.

To illustrate how unnecessary the medium of exchange function is in this particular case, we could equally well have argued that Ne-

braska, Florida, and Idaho could have solved their double coincidence problem with a different convenient "social invention" – credit. If people in Nebraska had taken out a loan of oranges from Florida, and traded some of them for potatoes from Idaho, the loan could be repaid in wheat. The only issue remaining is that Nebraska must be able to gauge how much wheat an orange is worth. To accomplish this, they all settle on a standard unit of account which they might call a 'dollar', and thus by comparing their goods to a dollar's worth, Nebraska and Florida can mutually agree upon whether the loan has repaid. Note that here, the emphasis is on the unit of account function and practically no mention is made of the fact that a dollar might actually also be a physical thing that can be traded directly and serve as a medium of exchange.

Thus we have a drastically different story of why money might be useful which solves the same problem. When physical money is in short supply, it is possible for traders to continue on without it, simply by denominating their loans in the standard of value the physical money is meant to embody. The barter problems set up in modern textbooks are therefore misleading in that one does not actually need money to solve them – an alternative is credit without a medium of exchange. Because there are multiple solutions to this problem theoretically, it is not so surprising that the emphasis the barter narrative has placed on the medium of exchange function has led to misinterpretation of the history.

III. Adam Smith and the barter narrative

One notable example of such a misinterpretation comes out of Smith's seminal text, *An Inquiry into the Nature and Causes of the Wealth of Nations*, in which there is an entire chapter devoted to "...the Origin and Use of Money". In this chapter, Smith contends that the double coincidence of wants problem must have stimulated the invention of money by means of a commodity "few people would be likely to refuse" becoming a widespread medium of exchange.

> "But when the division of labour first began to take place, this power of exchanging must frequently have been very much clogged and embarrassed in its operations. One man, we shall suppose, has more of a certain commodity than he himself has occasion for, while another has less. The former, consequently, would be glad to dispose of; and the

> latter to purchase, a part of this superfluity. But if this latter should chance to have nothing that the former stands in need of, no exchange can be made between them. The butcher has more meat in his shop than he himself can consume, and the brewer and the baker would each of them be willing to purchase a part of it. But they have nothing to offer in exchange, except the different productions of their respective trades, and the butcher is already provided with all the bread and beer which he has immediate occasion for. No exchange can, in this case, be made between them. He cannot be their merchant, nor they his customers; and they are all of them thus mutually less serviceable to one another. In order to avoid the inconvenience of such situations, every prudent man in every period of society, after the first establishment of the division of labour, must naturally have endeavored to manage his affairs in such a manner, as to have at all times by him, besides the peculiar produce of his own industry, a certain quantity of some one commodity or other, such as he imagined few people would be likely to refuse in exchange for the produce of their industry." – Smith, 1776

Smith goes on to say that metals are an excellent candidate for such a commodity since they are commonly durable, fungible, divisible, and easy to transport. He goes on to give examples of commodities which presumably filled this function in historical economies:

> "Salt is said to be the common instrument of commerce and exchanges in Abyssinia; a species of shells in some parts of the coast of India; dried cod at Newfoundland; tobacco in Virginia; sugar in some of our West India colonies; hides or dressed leather in some other countries; and there is at this day a village in Scotland, where it is not uncommon, I am told, for a workman to carry nails instead of money to the baker's shop or the ale-house." – Smith, 1776

Thus, Smith argues for the barter narrative: as economies developed finer divisions of labor, the double coincidence of wants problem grew and so people began to stockpile commodities which would be acceptable in all trades and these commodities can be called money. However, history shows that these societies Smith relies on for his argument could not have relied upon money as a medium of exchange,

because there just was not that much money to go around to fulfill the needs of ordinary people. At the time, these societies *were* using money, but rather as a unit of account. What we often think of as the primary function of money in modern textbooks and even what Adam Smith thought of as the primary function of money, was not what money was primarily used for. As anthropologist David Graeber points out, "[W]hat Smith describes was really an illusion, created by a simple credit arrangement...[Smith's examples] were ones in which people were improvising credit systems, because actual money – gold and silver – was in short supply" (Graeber, 2011).

> "Employers in Smith's day often lacked coin to pay their workers; wages could be delayed by a year or more...The nails were a de facto interest on what their employers owed them. So they went to the pub, ran up a tab, and when occasion permitted, brought in a bag of nails to charge off against the debt...The law making tobacco legal tender in Virginia seems to have been an attempt by planters to oblige local merchants to accept their products as a credit around harvest time. In effect, the law forced all merchants in Virginia to become middleman in the tobacco business, whether they liked it or not; just as all West Indian merchants were obliged to become sugar dealers, since that's what all their wealthier customers brought in to write off against their debts." - Graeber, 2011.

Thus, though John Smith cites these various commodities as historical examples of money emerging as a medium of exchange to solve the inefficiencies of barter, the evidence Graeber points to argues that the stage for their emergence was not set by barter, since the records of their actual behavior indicates the goods were primarily used to settle debts which were denominated in conventional money. The account of dried cod in Newfoundland is most explicit, and was written by the accountant Thomas Smith in 1832.

> " 'At Newfoundland, it is said, that dried cod performs the office of money; and Smith makes mention of a village in Scotland where nails are made use of for that purpose.' ... neither of these articles ever was used or could be used as money; and had Mon. Say, instead of servilely copying from Adam Smith and others, almost verbatim,

only taken the pains to investigate cases, he would have soon found out this. A very considerable intercourse has long existed betwixt some of the ports of France and one portion of Newfoundland, and he might easily have ascertained from any of the traders in those ports, as to the fact he mentions... No doubt when a person there is in possession of codfish, fully cured or fit for market, he can at all times obtain in return for them any articles that he may require; he has only to go to a store keeper, tell him that he has got the fish and state the articles he wishes in return and a negociation is immediately entered into. But the fish are not taken as money, neither do the parties make a swap of it, that is, make a rough exchange; on the contrary they make a fair a regular barter, calculating the exact value of the articles on each side, according to the rates they agree on;... If the parties are on the French side they use the term livre, if on the English it will be the pound and its diminutives, shillings and pence... a balance is struck. Should that be against the planter[4] he generally engages to pay it in fish at a future period, seldom having any other means. Should it be in his favour the merchant gives him a draft for the amount, either on France or England, which he pays away. In the English settlements such drafts for sums varying from five shilling to five pounds, pass as cash, and will circulate there for years before being sent home, being in fact almost the only circulating medium." - Smith, 1832

In short, dried cod didn't really fulfill any of the three functions of money – it merely served as a means of payment. Passages like the one above highlight the difficulty in accepting examples from the past that writers considered to be money: the three-function definition of money is actually very stringent. The examples used by Adam Smith to solve the coincidence of wants problems were only sometimes money, and less than half of them were conclusively used as media exchange.

IV. Credit and Barter – historical difficulties

The problem with evaluating whether money ever emerged according to the barter narrative is that the conditions a historical society

[4] 'planter' is a word used at the time to mean 'fisherman'.

would have to meet to be a barter economy are strict already, and the three function definition of money excludes devices, like credit, which solve some of the essential problems but are not themselves media of exchange. Evidence proving the barter narrative would have to show two things:

1. An economy dominated by barter, meaning direct simultaneous exchange of goods;

2. The emergence of a commodity in that economy which fulfills the unit of account and store of value function, but removed the coincidence of wants problem through the medium of exchange function.

Of these two requirements perhaps the hardest one to substantiate historically is that a barter economy based on simultaneous direct exchange ever existed.

> "Barter is at once a cornerstone of modern economic theory and an ancient subject of debate about political justice, from Plato and Aristotle onwards. In both discourses, which are distinct though related, barter provides the imagined preconditions for the emergence of money. Why should anthropologists be interested in logical deductions from an imagined state? No example of a barter economy, pure and simple, has ever been described, let alone the emergence from it of money; all available ethnography suggests that there never has been such a thing. Nevertheless, there are economies today which are *dominated* by barter"– Humphrey, 1985

While there have certainly been societies that used barter, there are no examples of economies relying on barter for trade between neighbors. Barter ordinarily "takes place between strangers, even enemies"(Graeber, 2011). In a way, barter is an extreme case of credit where the loan is repaid instantly. For interactions between family members or neighbors, there is no need for this kind of strict requirement since debts can be repaid in a variety of ways over a flexible time span. Between strangers and enemies however, each party must be wary that the other is not going to murder, steal, or both. Barter is thus ritualized, and pushed into the margins of societal activity.

V. Four Merchant Model

Using four players in a simple connected network, a variety of outcomes relevant to the functions of money can be demonstrated. One important result is that using a system of credits (loans) no more complex than those written onto clay tablets in the Ur III dynasty of Old Babylon (2000 - 1600 BC), it is possible to gain all three functions of money. The loan contract by definition fulfills the unit of account function and is a store of value, and when traded becomes a medium of exchange. This is particularly relevant to the barter story because while there are no historical economies based around barter as a primary mode of exchange, ancient Babylon contained a wealth of sophisticated banking operations inside their temples, leading to a widespread use of contract loans throughout the society and the legal codification of contract law to go with it. The model that follows uses four merchants in a network structure because it is relatively simple to model the standard problems with barter, the use of credits to solve them, and can be used to simply analyze the profitability of becoming a middleman due to the complementarity of the goods being traded.

VI. Model Overview

There are four producers of goods in a primitive economy, situated in a circle around a treacherous mountain. In their native tongue they are named after what they produce (the grain producer is named 'Grain', and so on). Each player can talk only to a neighbor a quarter of the way around the mountains: the mountains permit noone to pass them and thus it is impossible for a player to either communicate or enforce contracts with the player opposite (over the mountains, see fig. 5). Each player specializes in the production of a specific unit goods vector: $\mathbf{W}, \mathbf{G}, \mathbf{B}$ or $\mathbf{S}$. For instance, when Wood makes a unit of output I refer to it as $\mathbf{W} = (1, 0, 0, 0)$. Similarly, when he produces x units of output, I refer to it as $x\mathbf{W} = (x, 0, 0, 0)$.

Now, for simplicity take the case of homogeneous preferences. Let the utility of every producer be dependent on their holdings vector $\mathbf{h} = (h_1, h_2, h_3, h_4)$ in the same way:

$$u(\mathbf{h}) = \mathbf{1} \cdot \mathbf{h}^k = \sum_{i=1}^{4} h_i^k \quad k \in (0, 1] \tag{1}$$

The benefits of this utility function are that (1) it is easy to compute

and (2) it fulfills the usual conditions of utility:

1. Twice continuously differentiable in any good:
2. Increasing: $\partial_{h_i} u = k h_i^{k-1} > 0$
3. Concave: $\partial^2_{h_i h_j} u = \begin{cases} k(k-1)h_i^{k-2} \leq 0 & i = j \\ 0 & i \neq j \end{cases}$
4. Marginal utility goes to infinity in the low consumption limit:

$$\lim_{h_i \to 0} \partial_{h_i} u(h_i) = +\infty$$

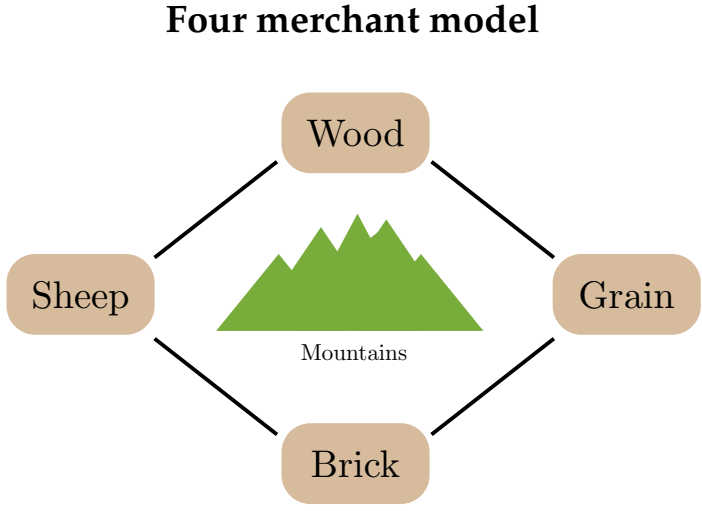

Figure 1: The setup of the four merchant model. Each producer has the ability to trade with their neighbor, but is unable to communicate or enforce contracts with the producer over the mountains.

VII. Barter solution

The lack of communication over the mountins doesn't hinder a pareto-optimal outcome *if* there is, in addition to homogeneous preferences, homogeneous production. Given that no producer has any preference for any particular good, and each starts out with the same amount a of their specialized resource – Wood has $a\mathbf{W}$, Grain has $a\mathbf{G}$ etc. – an efficient allocation (which is also very egalitarian) can be reached in four trades:

1. Wood, holding $a\mathbf{W}$, knows that Grain holds $a\mathbf{G}$ and that Sheep holds $a\mathbf{S}$. Since goods are preferred equally, Wood is indifferent to a trade with Sheep or a trade with Grain. Given that one is chosen, trading must commence until there are no pareto improving moves left. It is easy to see if Wood chooses Grain, he gives her $(a/2)\mathbf{W}$ in exchange for $(a/2)\mathbf{G}$ in return.

2. Next, noticing that a similar situation would occur between the sheep and brick producers: Brick gives Sheep $(a/2)\mathbf{B}$ in exchange for $(a/2)\mathbf{S}$ in return.

3. Now that Wood has $(a/2)[\mathbf{W}+\mathbf{G}]$ and Sheep has $(a/2)[\mathbf{B}+\mathbf{S}]$, Wood can give Sheep $(a/4)[\mathbf{W}+\mathbf{G}]$ for $(a/4)[\mathbf{B}+\mathbf{S}]$ in return.

4. Similarly, Grain can give brick $(a/4)[\mathbf{W}+\mathbf{G}]$ for $(a/4)[\mathbf{B_r}+\mathbf{S_h}]$ in return.

At the end of these four trades, each player holds and is able to consume $\mathbf{h_f} = (a/4, a/4, a/4, a/4)$. This final allocation yields

$$u(\mathbf{h_f}) = \sum_{i=1}^{4} h_i^k = 4\frac{a^k}{2^k} = 2^{2-k}a^k \tag{2}$$

as compared with the utility of the initial allocation

$$u(\mathbf{h_i}) = \sum_{i=1}^{4} h_i^k = a^k \tag{3}$$

The barter solution gives a factor of $2^{2-k}a^k$ higher utility, which is an improvement since $k \in (0,1) \implies 2^{2-k}a^k > 1$. This has some nice features. When marginal utility diminishes quickly, i.e. when k is close to zero, the gains from this kind of trade are very high and utility can be increased for every player asymptotically up to four times its original level.

Implications and features of barter without money

The barter case described above includes no media of exchange, no units of account, and no stores of value. Despite this, the result of this trading is optimal in a utilitarian sense. Given (a, a, a, a) to distribute among four players, one could not have done better in terms of total utility. In addition, every good made its way around the mountains by

a sequence of mutually agreeable trades. In this situation there can be no role for money to play. The usual objections to barter: transaction costs, double-coincidence of wants (Jevons, 1875), and identification costs (Alchian, 1977), don't apply as everyone is always willing and able to trade something with their neighbor to facilitate trade.

> "In real life, of course, things are more complicated; we are 'awash' in trading intermediaries because we cannot easily discover and exploit potential gains from trade without them." - Clower, 1995

If we were to keep homogeneous preferences but get rid of homogeneous production, barter would fall apart.

VIII. Borrowing solves a broad class of trading problems

One way we can easily see how money may arise as a unit of account is to imagine that our land is hit by a drought, and no sheep or wheat can be produced. In this situation, though units of brick may highly valuable to everyone, there's no way for anyone to obtain benefits from trade using a traditional scheme of sequential transactions. In this system, every trade must be improving to both players, and since in a 'primitive' world there's no notion of credit (yet), there's no incentive for Brick or Wood to trade with Grain and Sheep. Suppose that Grain creates the world's first promissory notes specifying on a clay tablet – as was done in Babylonian times – a debt of some number w units of wood to be paid to the bearer of the clay tablet. Suppose also that she creates another tablet denoting a debt of some number b units of brick. For the sake of convenience, I denote the tablet with debt in terms of w units of wood as $\$_w$, and the tablet with debt in terms of b units of brick as $\$_b$.

Now, if Grain completes a trade of $\$_b$ for $(w + \epsilon_w)\mathbf{W}$ with Wood, and a trade of $\$_w$ for $(b + \epsilon_b)\mathbf{B}$ with brick, then she can redeem her tablets by giving Wood $b\mathbf{Br}$ and Brick $w\mathbf{W_o}$. In this way, she keeps $\epsilon_w\mathbf{W} + \epsilon_b\mathbf{B}$ for herself.

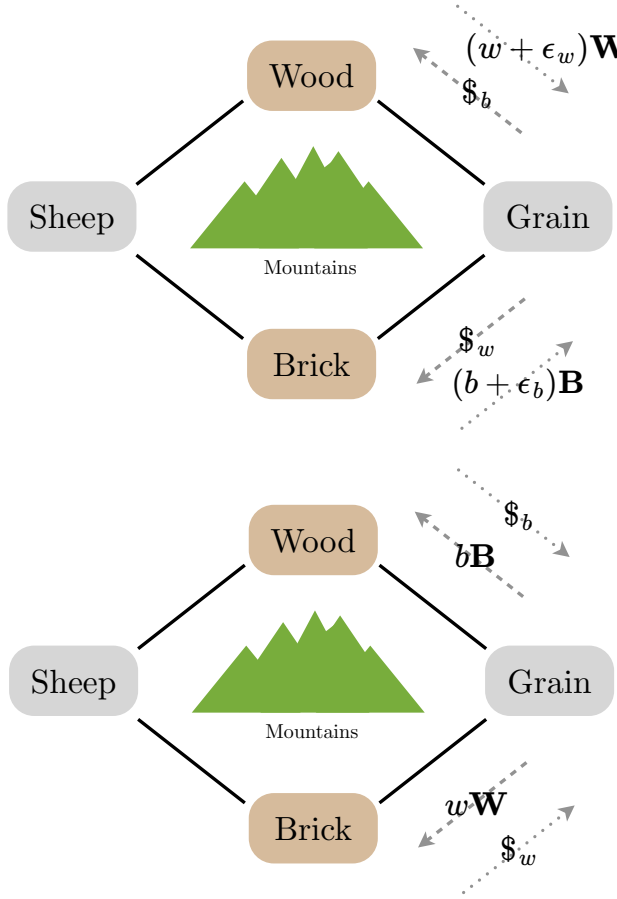

Figure 2: Steps 1 and 2 of Grain's solution to the drought. First, she issues $\$_b$ and $\$_w$ as loan contracts with Wood and Brick in exchange for wood and brick. Then, her creditors collect on their loans and return the loan contracts. This allows Grain to make a profit of $\epsilon_w \mathbf{W} + \epsilon_b \mathbf{B}$ for herself.

Merchant profits using the functions of money

By utilizing credit in a clever way, Grain has become the worlds first money-wielding merchant. This form of trading can make use of every aspect of money as defined by Hicks (1967): all that's required is to say that some time has passed between the issuing of the promissory notes and the claiming of the goods written in the contracts. As a medium of exchange, the promissory notes fulfill a role as an interme-

diate good solving the double coincidence of wants problem, albeit in a closed loop. Grain – initially – has nothing to offer Brick or Wood, so the coincidence of wants problem exists. By creating what is essentially a unit of account to handle credit, Grain can benefit herself by enforcing contracts with Brick and Wood, even though neither Brick nor Wood can enforce contracts with eachother.

This example shows a common theme in the emergence of commodity-backed monies: when the medium of exchange condition is fulfilled, the unit of account condition naturally follows. That is, when it makes sense to players to use an intermediate in exchange, price ratios and exchange rates therefore originate from the use of that intermediate. For instance, due to the intermediate promissory notes, the exchange rate Brick sees between wood (**W**) and brick (**B**) is $\$_w/(b+\epsilon_b)$, which is a price for wood in terms of Grain's promissory notes [5] . On the other hand, before the trades even took place, the loans were by definition units of account. Therefore, this system of credit-money demonstrates that the taking on of debt to personal gain is a plausible alternative to the double coincidence of wants narrative, which stresses the origin of money in transaction costs alone.

Grain's profit

Without considering any costs of issuing the notes, Grain gains $\epsilon_w\mathbf{W} + \epsilon_w\mathbf{B}$ from her scheme. There is a limit however to what can be supported as Grain's profit in this kind of system. The first thing to consider is that for this to work, each player must be at least as well off at the end of the trade. This means that

$$u(\mathbf{h_F}) > u(\mathbf{h_I}) \tag{4}$$

for all players. In the context of the utility function and example I have been using, if Brick produces $q_B\mathbf{B}$ every turn and (as is commonly assumed) there is a discount factor of β on consumption in the future, then there are two approaches to determining acceptable trades:

[5] Though the issuing of credits in a Babylonian way fulfills the three standard functions of money, another appropriate definition of money for the loan contracts circulating in this model is an Aristotelean one. A direct effect of the loan contracts in this model is that they establish an exchange rate between goods in equilibrium. There can be no more aristotelean form of money than that which "makes all things commensurable, as money is the universal standard of measurement [of exchange value" (Monroe, 1924)

One-Shot Solution

When Grain offers Brick one credit, and doesn't expect to issue in the period following, the only acceptable trades must satisfy:

$$(q_B - b - \epsilon_b)^k + \beta(w^k + q_B^k) \geq (1+\beta)q_B^k \tag{5}$$

This implies that Brick is indifferent when

$$(q_B - b - \epsilon_b)^k + \beta w^k - q_B^k = 0 \tag{6}$$

For any pair (b, w), the best possible ϵ_b supported in this trade is

$$\epsilon_b = q_B - \left[q_B^k - \beta w^k\right]^{1/k} - b \tag{7}$$

For Wood, the same kind of restrictions hold:

$$\epsilon_w = q_W - \left[q_W^k - \beta b^k\right]^{1/k} - w \tag{8}$$

This implies that the utility gained by Grain when she denominates $\$_b$ and $\$_w$ is

$$u(\vec{\pi}) = \epsilon_b^k + \epsilon_w^k = \left[q_B - \left[q_B^k - \beta w^k\right]^{1/k} - b\right]^k + \left[q_W - \left[q_W^k - \beta b^k\right]^{1/k} - w\right]^k \tag{9}$$

This implies the first order conditions:

$$\begin{aligned}\partial_b u(\vec{\pi}) = 0 = \\ \beta b^{k-1}\left[q_W - \left[q_W^k - \beta b^k\right]^{1/k} - w\right]^{k-1}\left[q_W^k - \beta b^k\right]^{(1-k)/k} \\ - \left[q_B - \left[q_B^k - \beta w^k\right]^{1/k} - b\right]^{k-1}\end{aligned} \tag{10}$$

$$\begin{aligned}\partial_w u(\vec{\pi}) = 0 = \\ \beta w^{k-1}\left[q_B - \left[q_B^k - \beta w^k\right]^{1/k} - b\right]^{k-1}\left[q_B^k - \beta w^k\right]^{(1-k)/k} \\ - \left[q_W - \left[q_W^k - \beta b^k\right]^{1/k} - w\right]^{k-1}\end{aligned} \tag{11}$$

As can be clearly seen from the above equations, this is a pretty tangled set of first-order conditions. Therefore, I turn to a numerical solution. First, however, let me consider what happens in steady state.

Steady-State Solution

When Grain gives Brick a note in exchange for $(b + \epsilon_b)\mathbf{B_r}$ every turn, the trades must satisfy:

$$(1+\beta)(q_B - b - \epsilon_b)^k + (1+\beta)(w^k) \geq (1+\beta)q_B^k \tag{12}$$

This implies that the discount rate β has no effect on the outcome since the $(1+\beta)$ can be dropped from both sides. Indifference implies equality and:

$$(q_B - b - \epsilon_b)^k + (1+\beta)(w^k) \geq (1+\beta)q_B^k \tag{13}$$

Similar to before:

$$\epsilon_b = q_B - \left[q_B^k - w^k\right]^{1/k} - b \tag{14}$$

This is to be expected: *the steady-state solution is merely the one-shot solution with no discount rate β.*

IX. Numerical Solution

As an alternative to the mind-numbing slog of solving the first order conditions, it's convenient instead to simply solve for the maximum profit over a grid of possible (b, w) pairs (equivalent to a numerical solution of the first order conditions). When parametrized in b and w, the level sets of the profit $u(\vec{\pi})$ can be plotted and the location of the maximum value found. An example of this numerical solution method can be seen in fig. 3 (below).

This particular optimum trade is convenient to demonstrate, while others will depend more complexly on the specification of k, β and the ratio q_W/q_B. If Wood and Brick start out with their initial holdings of $(q_W, 0, 0, 0)$ and $(0, 0, q_B, 0)$, respectively, and $q_W = q_B$, then their initial utilities are the same: $q_W^k = q_B^k$. Since $k = 1/2$, however, they are both indifferent between their initial holdings and final holdings of $(q_W/4, 0, q_B/4, 0)$:

$$u((q_W/4, 0, q_B/4, 0)) = \sqrt{q_W/4} + \sqrt{q_B/4} = \sqrt{q_W} = u((q_W, 0, 0, 0)) \tag{15}$$

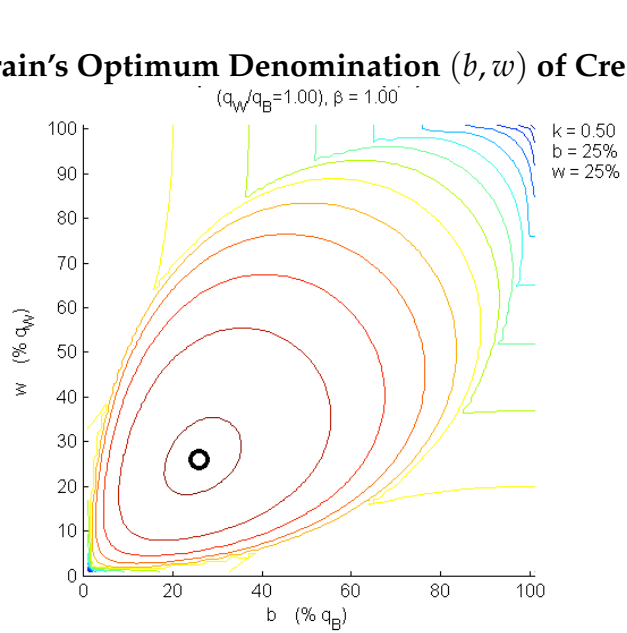

Figure 3: A plot of the contours of the $u(\vec{\pi})$ over (b, w) pairs. The optimum point, represented by a black circle, tells Grain exactly how much brick $b\mathbf{B}$ she should owe Wood and how much wood $w\mathbf{W}$ she should owe Brick if she wants to maximize the value of the profit she gets from the trade.

Since the total amount of each good is preserved, however, this gives Grain an initial holdings of $(0, 0, 0, 0)$ and a final holdings of $(q_W/2, 0, q_B/2, 0)$, yielding a utility $\sqrt{2}$ times that of either Wood or Brick. Being the middleman definitely paid off for Grain in this case.

X. Substitutes and Complements

The optimal (b, w) pair depends on β and k in a way that is instructive of conditions for the emergence of money. Examining a steady-state solution $\beta = 1$, and varying k (a measure of substitutability between wood and brick), the behavior of the optimal denomination of credit changes dramatically. The first thing to notice is that for a utility function of the form:

$$u(\mathbf{h_f}) = \sum_{i=1}^{4} h_i^k \tag{16}$$

Indifference curves near $k = 1$ look like *perfect substitutes*:

$$\lim_{k\to 1} MRS = \lim_{k\to 1} \frac{\partial_{h_i} u}{\partial_{h_j} u} = \lim_{k\to 1} \frac{h_j h_i^k}{h_i h_j^k} = 1 \tag{17}$$

While indifference curves near $k = 0$ look like *perfect complements*:

$$\lim_{k\to 0} MRS = \lim_{k\to 0} \frac{\partial_{h_i} u}{\partial_{h_j} u} = \lim_{k\to 0} \frac{h_j h_i^k}{h_i h_j^k} = \frac{h_j}{h_i} \tag{18}$$

In varying k from $k = 0$ to $k = 1$ slowly, and solving for the optimum (b, w) at every step, it's possible to find the ratio of Grain's utility to the initial value of Wood or Brick's utility. When this is done, a smooth curve is formed which shows that the most utility – relative to Brick and Wood – Grain can get of the system occurs when wood and brick are complementary goods. Also, the only case in which there are no potential gains from trade is when the goods are perfect substitutes.

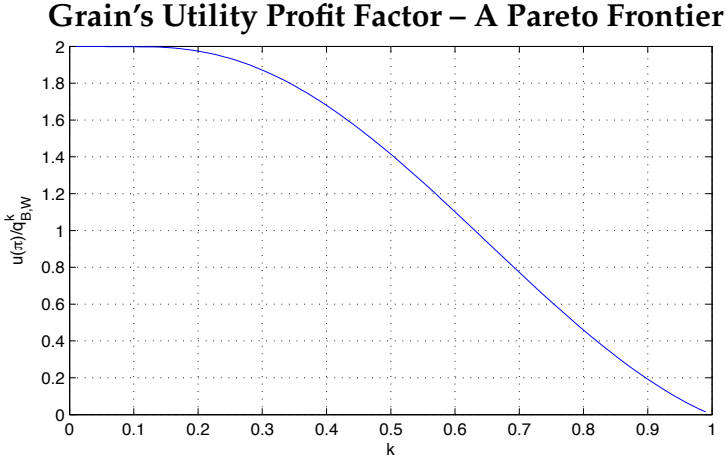

Figure 4: The ratio of Grain's per-period utility gained from trade to the maximum profit of Brick of Wood without trade as a function of k, i.e. $u(\vec{\pi}, k)/q^k_{B,W}$. This graph demonstrates the relationship between substitutability and how profitable creating an elementary system of promissory notes can be. At the center, where $k = 1/2$ (as in the trade before), notice that the value of the ratio is $\sqrt{2}$.

This result that the profits from trade using money is highest when the goods themselves are complements is relevant to the history of money. During the development of early economies, there was an expansion of productive processes that required complementary inputs. For example, for a specific amount of obsidian a corresponding amount of sinew and wood was required to craft a spear. How ever much more sinew or wood one was granted, the crafstman could not

create another spear until all three production inputs were provided in acceptable proportions.

In the transfer from early hunter-gatherer societies to agrarian ones it is consistent with the history to suppose that the development of technology could be represented in the four-merchant model as a gradual decrease in k for individuals in the habit of creating finished goods. Since the rewards to being the middleman in such a case would be higher, it's possible that the role of trader itself was created in part by the increasing complementarity of production inputs. This is consistent as the time period (circa 2,000 BC) gives us ample examples of markets, and the emergence of organized production requiring multiple inputs. Thus, a simple model of credit money based on actual ancient loan contracts lends support to the credit theory narrative of money, yields gains from trade higher than those from barter, and exhibits features consistent with the history of production technology.

XI. Competition

In the model, it is unlikely that Sheep would go long before realizing that Grain was benefitting from issuing her promissory notes. In response, Sheep could do the same thing, issuing promissory notes with slightly more favorable terms. Since preferences are homogeneous, and we already know the utility from Grain's profit, the solution to this problem is merely a game of descent on the manifold of Grain's profits (see figure 4). This competition is a form of Bertrand competition since Sheep and Grain are only choosing the denomination of their credit tokens, meaning that they're setting the exchange rate between Brick and Wood. In other words, Sheep and Grain are price-setters. With no collusion, it is clear that Sheep and Grain would reach an equilibrium outcome where neither of them makes a profit, as in the standard two-firm Bertrand case.

XII. Four-merchant model as applicable to Babylon circa 2000-1600 BCE

Because there are so many examples of catalogued primitive currencies, and because the ways in which they are used are so widely varied (Einzig,1966), it is difficult to conclude with a strong statement that solving inefficiencies of barter with a medium of exchange *never* led to improvements in trade, or that it was *never* a part of the emergence

of money in the three function definition. However, ancient Babylon is rich with historical examples of credit that lend themselves much more fruitfully to the thesis that wide scale trade did not encounter a significant double coincidence of wants problem. Instead, there were large institutions which set the precedent for the modern economy by establishing weights and measures, and that only after such units of account were in place did media of exchange fully take off.

In the history of civilization, the kingdoms of mesopotamia occupy a unique position. They are regarded as the first political organizations to have organized written systems of law in recorded history. Of the several thousand contract documents that survive from the era (2000 - 1600 BC), a majority of them concern loans (Skaist, 1994). As the cuneiform that was impressed into the clay to record these transactions has survived the millenia that followed their use, many researchers have had the time to study them and interpret their use in Old Babylon. The employment of these contract loans predates the development of true coinage by at least a millenium, and therefore offers insight into the early development of money, at least insofar as it concerns facilitating trade through the convention three-function definition of money.

Temples played the role of Grain in creating credit money

In the four-merchant model, players were situated around a mountain and thus could not communicate. On the watershed of ancient Babylon, there were no such mountains. However, the mountains did not play a role in inventing credit money in the Four-merchant model – they simply set the stage for competition between Sheep and Grain. All that was required for credit money to emerge was for a trading intermediary to connect trading partners and realize profits due to the complementarity of those goods. In ancient Babylon, the financial transactions of the day were legally tended to in temples and by temple scribes. The temple was not only a religious center with economic and legal obligations: the religious and the commercial spheres were not separate, and this is no better evidenced than by the fact that some loan documents have gods as creditors, and other documents formulate vows to the gods in legal loan terminology (Harris, 1960). On the whole, the temple was an institution with pervasive legal authority and influence, and a perfect candidate for the birthplace of money and banking.

The Role of the Temple in Ancient Babylon

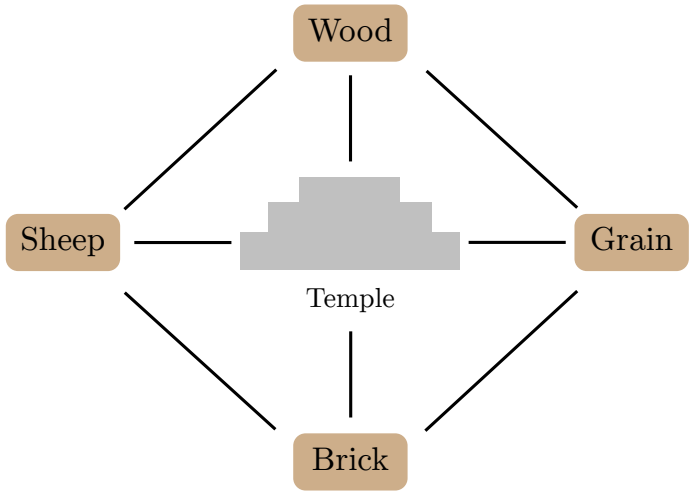

Figure 5: The setup of the four merchant model in ancient babylon. Each producer has the ability to trade with their neighbor, but is also able to communicate and enforce contracts with any producer through the temple.

With the temple at the center organizing loans, the potential of the temple to make profits from trade are enormous. If any two economic actors in the society produce complementary production inputs, the temple has the potential to make profits both by loaning out production inputs at interest and by using a credit-money system to facilitate trade. As an entity with the legal power to levy taxes, the Babylonian temples thus had both the legal authority and the economic power to standardize weights and measures and codify units of account.

XIII. Credit was pervasive in the Babylonian economy

In the abstract to *Shepherds, Merchants, and Credit: Some observations on lending practices in Ur III Mesopotamia*, Steven Garfinkle writes that

> "...Despite the overwhelming scale of the institutional economies, there was significant room for non-institutional households to pursue economic gains through money-lending. This entrepreneurial activity took place in an economy that was familiar with a sophisticated range of possible credit transactions." – Garfinkle, 2004

He later supports this with an exposition:

> "A debtor might owe an obligation to the temple of one of the chief gods of the pantheon, to a member of the royal family, to an urban entrepreneur, or to a relative of co-worker" – Garfinkle, 2004

Clearly, credit was pervasive in the babylonian economy. In the archives of two babylonians SI.A-a and Tūram-ili, a shepherd and a merchant, loans account for 68% and 17.5% of the respective documents (Garfinkle (2004, pg. 24)). Although Garfinkle cautions us to remember that "the surviving texts may not be an accurate reflection of the original volume or importance of any one particular activity within the economies of the households under consideration", the fact that a larger share of the Shepherd's documents were loan contracts captures the fact that facilitating trade was not the exclusive role of those people we might commonly call merchants. The distribution of loans in ancient Babylon is very indicative of the role of individuals and institutions, rather than markets, in creating financial devices that fulfill the goals of money.

XIV. Advanced finance emerged with the unit of account

In ancient Babylon, the temple served not only as a means of enforcing and codifying loan contracts, but also as a clearinghouse and storehouse as a precaution against drought. When peasant farmers ran out of grain, they could take out a loan at one-third interest to tide them over until the next harvest (Bromberg, 1942). While the early loan documents display most if not all of modern legal loan language (Skaist, 1994), a wide variety of more advanced financial instruments are also evident. Even derivatives appear in these documents following the enactment of the famous Law code of Hammurabi in the 18th century BCE:

> "In terms of contracts, one may recognise in this 48th law [of Hammurabi] a kind of contract that once translated into a more modern language would stipulate the following: A farmer who has a mortgage on his property is required to make annual interest payments in the form of grain, however, in the event of a crop failure, this farmer has the right not to pay anything and the creditor has no alternative but

to forgive the interest due. Experts in the field of derivatives would classify such a contract as a put option. In another words: if the harvest is plentiful and the farmer has enough grain to pay his mortgage interest, the put option would expire worthless." – Pauletto, 2012

XV. Conclusion

Credit and financial instruments in ancient Mesopotamia were pervasive and inextricable from the development of commodity money as a unit of account. In ancient Babylon, barter was likely present but evidently was not a factor in large commercial operations. At the time, Babylonian society was far more sophisticated than a simple collection of independent producers stockpiling for trade with each other. The prevailing socioeconomic hierarchy made such concerns obsolete by codifying tributes paid to the kingdom and the temples. Trade in such hierarchies thus never faced the double-coincidence problem in any significant way. Remarkably, through this hierarchy and the standard measures it imposed, a vast capitalism flourished in the fertile crescent with the establishment of contract law. Babylon set the stage for millennia of economic history with its economic and legal traditions at a time when the legal concept of money dealt primarily with payment of debt. Thus, the history suggests that money did not originate (at least in the middle east) as a solution to the inefficiencies of barter.

Mathematically, gains from trade via the Four-merchant model suggest that money originated more along the lines of institutionalized units of account, and credit, than by barter. Credit solves a broad class of problems, present in every economy, that barter can not. When a trading intermediary has no purchasing power, but is credit-worthy, it is still possible for them make a profit using credit: here barter has nothing to say. Barter, when viewed within the broader scheme of financial instruments, is an extreme case of credit where a loan is paid off instantly with some agreed upon interest and on specified terms of payment. To suggest that trading intermediaries were limited to such an extreme modus operandi ignores the historical reality that they were not. Thus, the codification of the loan contract in ancient Babylon, when combined with the historical evidence and simple thought experiments about the viability of credit, demonstrates that credit systems are a more historically and theoretically viable starting place for the emergence of money than barter.

References

[1] Alchian, A. (1977). "Why money." *Journal of Money, Credit, and Banking*, 9.

[2] Bromberg, B. (1942). "The origin of banking: Religious finance in babylonia." *The Journal of Economic History*, 2(1):77–88.

[3] Clower, R. W. (1995). "On the origin of monetary exchange." *Economic Inquiry*, XXXIII:525– 536.

[4] Einzig, P. (1966). "Primitic Money in its Ethnological, Historical, and Economic Aspects." Pergamon Press.

[5] Garfinkle, S. J. (2004). "Shepherds, merchants, and credit: Some observations on lending practices in ur iii mesopotamia." *Journal of the Economic and Social History of the Orient*, 47(1):1–30.

[6] Graeber, D. (2011). "Debt: The First 5,000 Years." Melville House Publishing.

[7] Harris, R. (1960). "Old babylonian temple loans." *Journal of Cuneiform Studies*, 14(4):126–137.

[8] Hicks, J. (1967). *Critical Essays in Monetary Theory.* Clarendon Press: Oxford.

[9] Humphrey, C. (1985). "Barter and economic disintegration". Man, 20(1):48–72.

[10] Jevons, W. S. (1875). "Money and the Mechanism of Exchange." Appleton.

[11] McConnell, C., B. S. F. S. (2012). Macroeconomics. McGraw-Hill, 19 edition.

[12] Osborne, D. K. (1984). "Ten approaches to the definition of money." Federal Reserve Bank of Dallas.

[13] Pauletto, K. . (2012). "The history of derivatives: A few milestones." EFTA Seminar on Regulation of Derivatives Markets, Zurich.

[14] Radford, R. A. (1945). "The economic organization of a p.o.w." camp. Economica, 12(48):189– 201.

[15] Skaist, A. (1994). "The Old Babylonian Loan Contract: its History and Geography." Bar-Ilan University Press.

[16] Smith, A. (1776). An Inquiry into the Nature and Causes of the Wealth of Nations. [Smith, 1832]

[17] Smith, T. (1832). "An Essay on Currency and Banking." Jesper Harding, Printer.

The Relationship between Monetary Policy and Asset Prices

A New Approach Analyzing U.S. M&A Activity

Brett R. Ubl[1]

Abstract

This article details the relationship between asset prices and monetary policy with a specific focus on the mergers and acquisitions market. The existing literature has studied extensively the link between monetary policy and stock prices and housing prices, but has not analyzed other assets, such as MA transactions. Monetary policy theory suggest that a negative shock to monetary policy that lowers interest rates increases asset prices. A lower interest rate decreases the cost of borrowing, raises investment levels (say for firms or home-buyers), and thus raises the asset price. Using a VAR methodology, the empirical evidence in this study, however, does not find this relationship between monetary policy shocks and MA activity. The response of MA activity – measured by average EBITDA multiple and the number of transactions – does not respond inversely to shocks in monetary policy.

Black Tuesday, the infamous Wall Street Crash of 1929, triggered the Great Depression, the most severe global recession since before the Industrial Revolution. The Great Depression began with this devastating drop in the asset prices of companies. Unfortunately, the Federal Reserve made critical errors in judgment and in philosophy that severely worsened the Great Depression for years. Since then, scholars have been better able to understand monetary policy, including its relationship with asset prices. In these efforts, scholars and monetary policymakers have hoped to avoid the consequences that can result from asset price crashes and even possibly prevent such crashes in the

[1]I would like to recognize several individuals who enabled me to complete this project. First, I wish to extend appreciation to Agata Rakowski and Dealogic who provided the data on U.S. M&A activity. Also, my professional experience as an investment banking analyst with Robert W. Baird & Co. developed my understanding of the M&A market. I am thankful for the constant support of the University of Notre Dame's Department of Economics, especially Professors Michael Mogavero and Mary Flannery. Finally, I owe a heartfelt thanks to Professor Timothy Fuerst. His comments and whistling were an invaluable resource in this process. Indeed, I am forever grateful for the opportunity to learn under the Whistling Professor.

first place. On Milton Friedman's 90th birthday, former Federal Reserve Chairman Ben Bernanke famously commemorated Friedman's scholarship in this field. Bernanke (2002) concluded his remarks to Friedman and the birthday party attendees stating, "Regarding the Great Depression, you're right, we [the Federal Reserve] did it. We're very sorry. But thanks to you, we won't do it again."

Just a few years later while testifying in front of Congress during his nomination to become Chairman, Bernanke falsely observed that no housing bubble existed to burst, noting that asset price increases in the housing market "largely reflect strong economic fundamentals" (Henderson 2005). Former Chairman Alan Greenspan suggested the housing price increases were merely "froth" in local markets (Henderson 2005). To the dismay of both chairmen, there was indeed a housing bubble and it collapsed. Combined with excessive risk taken by banks and financial institutions in the subprime lending market, the Great Recession resulted. Unlike the Great Depression, this time the Federal Reserve, under Bernanke's guidance, took enormous steps to provide liquidity, be a lender of last resort, and constantly strive to stabilize financial conditions. Although not perfect, most scholars would agree that the Fed's efforts were commendable and often ingenious during the Great Recession.

I provide this brief history of the two worst economic downturns in U.S. history to exemplify the important relationship between monetary policy and asset prices. In the Great Depression, falling stock prices were the trigger; in the Great Recession, housing prices took this role. It may not be practical to expect the Fed to prevent such collapses, but in the very least, an optimal response is required to minimize the potentially disastrous outcomes. However, the academic literature has so far only studied stock prices and housing prices. I argue that, just as housing prices were far off the radar of policy makers and scholars before the 2006-2007 collapse, other assets may be equally troubling in future downturns. The core aim of this paper is to extend the literature beyond stock prices and housing prices and consider the relationship between monetary policy and a third asset class – mergers and acquisitions ("M&A"). M&A activity is an enormous market, totaling more than 14,000 transactions in 2012 alone with an average transaction size over $200 million. This is not meant to be a prediction for the next recession, although the possibility certainly exists. In the very least, understanding the relationship between monetary policy and asset prices more broadly is a critical task that can benefit schol-

ars and policymakers.

With this aim in mind, the article will progress as follows. In Section I, I present an extensive literature review covering monetary policy as it relates to asset prices. Section II presents the Asset Price Channel, a hypothesis based on existing literature that conceptually explains the potential relationship between asset prices and monetary policy. Next, Section III applies this hypothesis to M&A activity specifically and then presents a discussion on M&A valuation and why this asset type is relevant to include in the monetary policy literature. Section IV and V describe the data along with the methodology for forming a model to test the Asset Price Channel. The data includes basic Taylor rule variables, the Federal Funds Rate ("FFR"), the ten-year Treasury rate, and M&A metrics including the number of transactions and the average EBITDA multiple. Section VI presents the results from the described models, showing no evidence to support the Asset Price Channel, contradicting the existing literature that studies stock prices and the housing market.

I. Literature Review Summaries

In this literature review, I discuss several topics concerning asset prices and monetary policy. First, scholars are divided on whether optimal policy rules should include asset prices. Related to this, empirical studies have examined both whether asset prices respond to monetary policy and whether monetary policy responds to asset prices. I also briefly review articles that link foreign asset prices with domestic monetary policy. Throughout this literature review, I emphasize that economists have only studies asset prices and monetary policy with housing prices and stock prices. Economists have not linked monetary policy to other asset classes, including M&A activity which is the focus of this article.[2]

Cecchetti et al. (2000) outlines a scenario in which asset price misalignments create undesirable instability in inflation and employment. In other words, booms cause busts, and busts are harmful to the macroeconomy. Considering historical cases of asset booms, the authors then

[2]By using Google Scholar and the University of Notre Dame's OneSearch for academic literature, I was unable to find any articles directly addressing M&A and monetary policy.

consider what steps central banks can take to avoid these pitfalls.[3] The authors advocate a "lean against the wind" strategy where central banks respond to booms by increasing the interest rate in order to counter rising asset prices and dampen boom-bust cycles.[4] This strategy includes asset prices in the policy rule to best stabilize inflation and output.

By examining forward-looking structural models of G7 economies from 1972 to 1998, Goodhart and Hofmann (2000) similarly contend that a monetary policy rule excluding asset price movements increases inflation and output gap variability because the information contained in asset prices is useful in forecasting future demand conditions. Bordo and Jeanne (2002) consider a stylized boom-bust dynamic model in stock and property prices. The thought experiment discusses the role of pre-emptive monetary policy. This sort of *ex ante* policy differs from policy rules that respond to an asset price bust only *ex post*, like an inflation-targeting rule. By compare moving averages of asset prices in OECD countries from 1970 to 2001, the analysis identified twenty-four stock booms and twenty housing booms.[5] The authors contend that a response to asset prices restricts monetary policy during a boom and is insurance against the risk of real disruption induced by the potential for a bust or even a moderate asset price reversal. In this way, they favor a policy rule that includes asset prices in order to yield tighter monetary policy *ex ante* before a boom develops.

Several scholars, however, hold the view that policy rules including asset prices yield sub-optimal results. Bernanke and Gertler (2001) evaluate a standard new-Keynesian model while also incorporating informational friction in credit markets. The model then simulates a shock of a five-period increase in the nonfundamental component of stock prices followed by a bust in the sixth period. The results show that an aggressive inflation-targeting rule dominates accommodative approaches in reducing both inflation and output variability. Placing a weight on stock prices does help marginally, but Bernanke and Gertler conclude this is not the optimal policy because of the practical

[3]The cases include the 1929 stock market crash, the 1980s housing and equity bubble in Tokyo, and the late 1990s crises in Southeast Asian equity and currency markets

[4]To clarify, the authors do not recommend that central banks should burst bubbles once they form as this could still lead to disastrous outcomes. Rather, they advocate for monetary policy that works to prevent bubbles from forming in the first place.

[5]This study diverges slightly from other analyses in that they consider optimal policy not only for busts but also more moderate asset price reversals following booms.

difficulties in separating fundamental from non-fundamental movements in stock prices.[6] Ultimately, the practical difficulties outweigh the marginal gains in policy outcomes. Carlstrom and Fuerst (2007) consider the inclusion of asset prices in monetary policy in a model with either sticky prices or sticky wages. A central bank response to share prices in the case of sticky wages does yield optimal policy because firm profits and share prices move positively with inflation. However, in a model with sticky prices, a central bank responding to share prices implicitly weakens its overall response to inflation because increases in inflation tend to lower firm profits, leading to suboptimal monetary policy. The authors conclude that, because of the sticky price model, monetary policy rules should not include asset prices.

Gilchrist and Leahy (2002) assess large movements in asset prices in the United States and Japan from the 1970s through the 1990s. Using this data, they consider various shocks to the economy, including asset price busts. They conclude that weak inflation targets produce huge swings in output. Regardless of including asset prices in the policy rule, this empirical study concludes that aggressive inflation-targeting yields the optimal outcome. Filardo (2000) employs a framework outlined by former Bank of England member Charles Goodhart that proposed policy rules that include broad measures of housing and stock prices. He dismisses this approach, primarily because of the difficulty in identifying the signs of nonfundamental movements in asset prices. Filardo illustrates that erroneous identification of price bubbles has significant unintended consequences that harm economic outcomes.[7] Even without this difficulty, he concludes that including asset prices has little impact in improving policy outcomes.

The corollary question asks whether asset prices respond to monetary policy. Bernanke and Kuttner (2005) conducted an event-study analysis by looking at daily data from FOMC decisions from 1989 to 2002 and tracking the movement in stock prices in response to monetary policy shocks. Using several modeling techniques, such as VAR forecasts, Bernanke and Kuttner conclude that an unexpected 25-basis-point cut to the Federal Funds Rate leads to a 1% increase in stock indexes on that same day. Rigobon and Sack (2004) use a VAR model

[6] This is the same critique that Cecchetti et al. considered, but then dismissed.

[7] As many of the critics have noted, identifying bubbles is no easy task. Recall that, even as late as 2005, Bernanke and the majority of central bankers did not realize the existence or extent of the housing bubble.

that employs an identification technique through heteroskedasticity. Examining the Dow Jones Industrial Average, SP 500, the Nasdaq, and the Wilshire 5000 from 1994 to 2001, these authors find very similar results to the Bernanke and Kuttner analysis. For example, an unanticipated 25-basis point increase in the short-term interest rate results in a 1.7% decline in the S&P 500.

Laevan and Tong (2012) take a deeper look at this question by examining varying responses by different types of firms. There should be variance among firms – those more dependent on external financing should have larger swings in stock prices due to a monetary policy shock. The data examines 20,121 firms across forty-four countries, with the average response of stock prices roughly 4:1 from an unexpected change in interest rates.[8] Firms are then classified as either dependent or (relatively) independent on external financing, interacting this variable with the monetary policy shock. Indeed, firms more dependent on external financing are disproportionately affected.

Prior to the housing price collapse beginning in 2006 that triggered the Great Recession, economists did not consider the damage that could be caused or triggered by a housing bubble. Several scholars and commentators have criticized that then-Chairman Alan Greenspan kept interest rates too low for too long leading up to the collapse of the bubble, allowing for easy lending and an increased demand for housing. According to this reason, the low interest rates fueled the bubble and allowed the housing market to overheat before eventually collapsing. From 2002 to 2006, the Federal Funds Rate was roughly 200 basis points below what the Taylor rule would have prescribed for policy makers. However, Bernanke (2010) has since argued that this thinking is flawed for several reasons. First, he states that the applicable Taylor rule looks at expected future inflation, not current inflation. The interest rates were on par with this revised monetary policy rule and were not too low. Bernanke also observes that the surge in housing prices began in 1998, implying that the timing of the start of the housing bubble rules out the period when interest rates were arguably too low (first in 2002 through 2006). Iacoviello (2005) similarly estimated a monetary business cycle that includes the housing market. By imposing collateral and borrowing constraints and simulating demand shocks on the housing market of nominal loans, he finds that "allowing the monetary authority to respond to asset prices

[8]It is generally assumed that the current inflation target of the Fed is approximately 2%.

yields negligible gains in terms of output and inflation stabilization." Other scholars disagree and believe the Fed should have acted otherwise. Taylor (2007) observes that monetary policy responded more effectively to inflation in the 1980s and 1990s and reduced boom-bust cycles in the housing market. He then claims that the Federal Reserve deviated from this previous action beginning in 2002. Using a counterfactual model of the housing market, he contends that the loose monetary policy failed to minimize the housing bubble and may have been a causal force in the rise of the housing bubble.

Just as they answered whether asset prices respond to monetary policy, Rigobon and Sack (2003) also study the reverse – the reaction of monetary policy to stock markets. According to the authors, stock markets have a significant impact on the macroeconomy primarily through the influence on aggregate consumption and the cost of financing to businesses. These effects play into the calculus of central bankers. Using the same VAR model from before, Rigobon and Sack establish an identification technique based on the heteroskedasticity of stock market returns. They conclude that a five percent rise in the S&P 500 increases the likelihood of a 25 basis point tightening by about one half. Bohl et al. (2007) study this same question by looking at the Bundesbank, tracking stock prices and interest rates in Germany from 1985 to 1998. Contrary to the evidence that Rigobon and Sack found in the U.S., the results in this study show that the Bundesbank did not respond to movements in stock prices, with one possible exception to the stock market crash of 1987. Bohl et al. states that "the theoretical rationale linking central bank reactions to asset prices is not yet sufficiently well developed to provide definite guidance."

Erler et al. (2013) analyze the real estate boom leading up to the Great Recession to determine if monetary policy responds to real estate asset prices. They set up a GMM model using real estate market data from 1980 to 2007 and then approximate both a Taylor rule and a Taylor-type rule with asset prices as possible monetary policy responses. The authors found a statistically significant negative response to real estate asset prices including a real estate dummy variable. In other words, the Fed actually lowered interest rates in the presence of a real estate boom, contrary to a "lean against the wind" strategy.

A related topic that several scholars have addressed is the relationship between domestic monetary policy and foreign asset prices, both if foreign asset prices respond to domestic policy and vice versa. Ida

(2011) examines a theoretical New Keynesian model to determine optimal monetary policy rules in an open economy. For simplicity, the model illustrates a two-country sticky price world. In this scenario, a positive foreign productivity shock leads to an increase in foreign asset prices. Assuming an open economy, this leads to increases in both foreign and domestic consumption. Ida argues that this increased consumption raises domestic asset prices despite no change to the fundamental values of domestic producers, creating a price bubble. This creates an opportunity for central bankers to consider this type of bubble when setting interest rates. Wongswan (2008) addresses this question using empirical evidence from fifteen foreign equity indexes in Asia, Europe, and Latin America with respect to movements in U.S. monetary policy. By observing high-frequency intra-day data on dates of FOMC announcements, he employs a model similar to that of Bernanke and Kuttner. The stock indexes increase between 0.5% and 2.5% with a 25-basis-point cut in the federal funds target rate. This reinforces the inverse relationship between asset prices movements and monetary policy shocks

II. Theoretical Outline of Monetary Policy Effects on Asset Prices

The Fed sets the money supply to a level that achieves a certain interest rate. But, how does the Fed determine the optimal interest rate? According to the Federal Reserve Act, the Fed has a dual mandate to stabilize prices and minimize unemployment (Carlstrom and Fuerst 2012). This simplifies to the objective of limiting the variability of inflation and output. John Taylor famously proposed an econometric model where the interest rate is a function of changes in the price level and changes in output. This has led to the development of various monetary policy rules, known as "Taylor rules." The most basic Taylor rule is an OLS regression depicted by Equation 1 below (Ball 2011):

$$r = r^n + a_Y \cdot (Y - Y^*) + a_\pi(\pi - \pi^T) \quad (1)$$

where (Y – Y*) is the output gap with Y being actual output and Y* is potential output and $(\pi – \pi^T)$ is the inflation gap with π^T being the target inflation.[9] An important component of the Taylor rule is the

[9]It is generally assumed that the current inflation target of the Fed is approximately 2%.

Taylor Principle, which states that the coefficient α_π should be greater than 1.0. This changes the nominal interest by more than the inflation rate, ensuring that the real interest rate actually adjusts to affect the real economy (David and Leeper 2007).[10]

One additional feature regarding the interest rate worth noting is the zero-lower bound on the nominal interest rate set by the Fed. That is, no person would save in exchange for a negative nominal return, but would rather simply hold money. So, the Fed cannot lower the nominal interest rate below zero. The Taylor rule, however, may still imply a negative interest rate. Consider monetary policy with the Taylor rule from Equation 1. Say, actual inflation equals the inflation target so the inflation gap is zero. Then, take $r^n = 1.0$ and $_Y = 0.5$. If the output gap is large enough (say -3.0), then the Taylor rule will suggest a negative nominal interest rate. Once a central bank reaches the ZLB in this scenario, it may lead to a liquidity trap. The model computes that the interest rate should be further lowered, but this is impossible due to the ZLB. Even worse, monetary policy is now too tight given the optimal response according to the Taylor rule. This further fuels a lack of liquidity and slows down the economy. A vicious circle– known as a liquidity trap – can develop, characterized by low levels of nominal interest rates, economic stagnation and potential deflationary periods (Bullard 2013).

Several examples exist of this ZLB scenario. Japan has been in a liquidity trap at the ZLB for most of the 1990s and is still facing this issue today. Since 2008, the U.S. and several other countries reached the ZLB during the Great Recession and are still challenged by strategies to exist these liquidity traps. As will be discussed later, this makes the FFR irrelevant because an econometric model based on a Taylor rule does not understand the ZLB constraint. Several policies are available to central banks to escape a liquidity trap. These policies including quantitative easing, purchasing long-term assets, and fiscal expansion (Bullard 2007). As an example of recent U.S. policy, the Fed has practiced quantitative easing, or buying long-term assets like mortgage-backed securities, at a rate of $85B per month. These policy options are often aimed at lowering the long-term real interest rate to provide greater liquidity and induce a robust recovery when the Fed can no longer lower short-term interest rates. For this reason, I contend that

[10]Recall the Fisher Equation where the real rate is the difference between the nominal rate and the inflation rate. Thus, to move the real rate, the nominal rate needs to move by a larger amount than the inflation rate movement.

including long-term interest rates in empirical analyses is relevant because the Fed's policy is no longer solely aimed at the FFR but is also targeting long-term rates such as the 10-year Treasury rate.

Before analyzing the potential effects of monetary policy on asset prices, it is necessary to understand how asset prices are determined. The classical theory of asset prices states that the price of an asset equals the present value of expected asset income (Ball 2011). The "expected" income derives from the rational expectations assumption, that is, people's expectations of future variables are the best possible forecasts based on all available information. Thus, two variables determine the present value: forecasts of future income and the interest rate to determine present values. Looking at stock price valuation, one can better understand the valuation method of asset prices. The future earnings of a firm flow to stockholders through dividends. Thus, the price of a stock is given by:

$$stockprice = \frac{D_1}{(1+i)} + \frac{D_2}{(1+i)^2} + \frac{D_3}{(1+i)^3} + ... \tag{2}$$

If the dividends are assumed to be constant, then this becomes a perpetuity valuation where the present value of the stock is:

$$stockprice = \frac{D}{i} \tag{3}$$

Or, as proposed by Myron Gordon, the Gordon growth model theorizes that a stock is determined by an initial expected dividend that is then expected to grow at a constant rate. In this case, the price of a stock is given by:

$$stockprice = \frac{D}{(i-g)} \tag{4}$$

Finally, it is important to understand the relevant interest rate, as it does not necessarily match the FFR, or the interest rate set by the Fed. Rather, $i = i^{safe} + \phi$ where i^{safe} is the risk-free rate, such as the rate on a ten-year Treasury bond, and ϕ is the risk premium of the asset that the owner receives as compensation for baring the additional risk. Together, i is known as the risk-adjusted interest rate.

Continuing with the valuation of stock prices, it is clear how monetary policy could affect asset prices. Using the Gordon Growth Model,

say D = \$2, i = 0.05, and g = 0.01. The price of the stock equals \$50. Now, let's say the Federal Reserve lowers the interest rate. This can have several transmission effects on the price of this stock. For one, the risk-free rate may decrease. As discussed earlier, the Federal Reserve controls the short-term, nominal rate. However, according to the expectations theory of the term structure, the long-term nominal rate is just the average of expected short term rates. Thus, assume the Fed lowers the interest rate such that the risk-adjusted i decreases to 0.04. In this case, the stock price would rise from \$50 to \$66.67.

Monetary policy could also affect the actual prospects of the firm's future earnings as well. The function for forecasting a firm's future earnings can take on several forms. Parameters may include management ability (M), historical performance (H), projected competitors (C), investments (I), and any number of other factors influencing production (P). Think of this forecast function in the general form of Equation 5 where any number of parameters could be used, but certainly investment is a critical variable.

$$Future\ Income = F(M, H, C, I, P) \tag{5}$$

Importantly in this function, investment has a positive effect on future income. Now, consider the function for investment, which includes parameters such as current capital accumulation (K), a productivity factor (Z), and the interest rate (i), given by Equation 6.

$$I = F(K, Z, i) \tag{6}$$

Again, assume the Federal Reserve lowers the interest rate. This in turn makes it cheaper for firms to borrow, thus increasing the firm's level of investment. Feeding Equation 6 into Equation 5, a lower interest rate that increases investment will also increase future income. According to the rational expectations assumption, market participants would include new information such as the Fed's decision to lower the interest rate in forecasting a firm's future earnings. Returning to the stock price example, this could increase D, g, or both. Let's say D increase to \$2.25 and g increases to 0.015 with i still lowered at 0.04. Now, the price of the stock increases further from \$66.67 to \$90. This general example helps illustrate the potential effects of monetary policy on asset prices, a mechanism I will refer to as the Asset Price Channel throughout this essay.

In summary, the Asset Price Channel suggests that a negative shock to the interest rate makes borrowing cheaper. This induces a higher level of investment, raising the growth prospects and, thus, the potential earnings for assets. Because assets have earnings potential over a long-period of time, a cut in the interest rate may also raise asset prices by decreasing the discount rate when determining present values of future earnings. The Asset Price Channel dictates an inverse relationship between shocks in monetary policy and movements in asset prices. Thus, the Asset Price Channel aligns with much of the literature. As Bernanke and Kuttner found, a 25 basis-points cut in the funds rate increased stock prices by about 1%. Likewise, many scholars such as Taylor believe low interest rates can fuel increases in housing prices.

However, the Asset Price Channel may not always hold for several reasons. First, the interest rate set by the Fed may not be a relevant interest rate in the valuation of assets. Above, we assumed that the short-term nominal rate – the FFR – influences both the risk-free rate and the rate at which firms borrow for investment projects. This may not necessarily be true. Again, assume the risk-free rate is the 10-year rate. This is determined by the average of the current 1-year nominal rate and the expectations for the 1-year nominal rates over the next nine years. If this holds, then the current monetary policy decisions of the Fed would only affect the current 1-year nominal rate. In averaging with the next nine years of short-term rates, it is plausible that this has an insignificant effect on the 10-year nominal rate. Likewise, if firms borrow at a rate other than the short-term nominal rate, then monetary policy shock would not necessarily influence firms' growth prospects. By the same reasoning, it is likely that the Fed's control of this short-term nominal rate does not transmit to the rate at which firms' borrow. In this event, the Fed's current monetary policy would not affect the valuation of stocks. Finally, the same could be said for the relevant interest rate at which households borrow in determining mortgage rates and housing prices.

In addition to potential flaws in the Asset Price Channel, I contend that both stock prices and house prices are not ideal assets for testing this theory with empirical evidence. Beginning with stock prices, it is very difficult to determine causality in the fluctuations of stock prices because price movements are virtually constant given the continual inclusion of new information. Empirical research, such as Bernanke and Kuttner, is limited to analyzing one-day movements in

stock prices on days in which monetary policy shocks occur. Although effective in determining one-day movements in stock prices, this may not be at all relevant if stock prices absorb this news and reverse the fluctuation over the course of days and weeks. It is nearly impossible to filter out any type of a reverse fluctuation (if one occurs) from the inclusion of other new information. Beyond one-day movements, stock prices cannot provide a testable experiment for lasting changes in asset prices from monetary policy shocks. Similar difficulties exist for the housing market where countless variables affect prices over a much longer period of time. One can observe broad movements in housing prices, but it is difficult to associate such long-term changes in housing prices with a one-day monetary policy shock. Thus, it is a daunting empirical challenge to observe the specific impact of monetary policy shocks both on housing prices and stock prices. For these reasons, I consider a third type of asset prices: M&A activity.

III. A New Approach: Mergers and Acquisitions

To begin this section, I emphasize that M&A activity has not been studied in relation to the effects of monetary policy on asset prices.[11] The only two types of assets considered in the literature have been stock prices and housing prices, even though M&A transactions are ideal for several reasons. First, M&A activity involves the equity prices of companies, just as stock prices reflect the equity value of public companies.[12] It follows that, if stock prices are relevant to study the effects of monetary policy on asset prices, then M&A activity must be relevant as well because they both measure the same type of asset. However, M&A transactions involve a multi-month process. Contrary to only observing one-day movements in stock prices, M&A processes have the time to absorb shocks in monetary policy and respond accordingly. This allows empirical research to more consistently observe the effects of shocks. Unlike investing in a house that covers multiple decades or the perpetuity nature of stock valuations, M&A investments often cover a three to seven year window. This is more

[11] The outline of the MA market and valuation methods follows the M&A investment banking guides by Breaking into Wall Street. ("Equity Value and Enterprise Value Questions Answers" 2012, "Valuation Questions Answers" 2012, "DCF Questions Answers" 2012, "LBO Model Questions Answers" 2012).

[12] Note that M&A activity can include either public or private companies. Public companies can be acquired either through divestures of specific divisions or through a private takeover.

likely to reflect the effect of monetary policy, which controls the short-term nominal rate. In the very least, M&A activity is a relevant asset class due to its enormous market size. In 2012 alone, over 14,000 M&A transactions were completed with an average value above $200 million. This empirical analysis of the effects of monetary policy on M&A activity provides an original approach to this literature and helps further understand the relationship between asset prices and monetary policy.

M&A transactions are either the merger of or purchase of companies, generally involving the sale of a majority stake or the entirety of a company. Broadly speaking, M&A involves two classes of acquirers: 1) a company acquiring or merging with another company; or 2) an investment institution, primarily a private equity firm, that acquires companies to include in an investment portfolio. The latter sort of acquisitions often involve a large portion of debt with only a minority of the acquisition being funded with equity. To understand this process, consider a typical private equity firm. The firm will raise capital in an investment fund and then acquire a group of companies, financing the acquisitions with debt. Each portfolio company has two primary goals: 1) use the investment from the acquisition to grow the company; and 2) generate profits that are used to pay down the debt. As the companies grow and the debt paid down, the private equity firm re-sells each company hopefully at a higher price due to growth. What is more, the firm receives a quantity worth the entire value of the company, which is sizably more than the original investment that was financed only partially with equity and mostly with debt. Even if only some of the portfolio companies grow and not all the debt paid down, the portfolio can post remarkable returns. Harris et al. (2013) has found that the average U.S. private equity fund outperformed the S&P 500 by over 3% annually. The next sections discuss more fully the elements of this market.

Asymmetric information is especially of concern in the M&A market. As noted earlier, over 14,000 M&A transactions occurred in 2012. Although this is a large market due to the size of each transaction, the frequency of transactions pales in comparison, say, to the thousands of stocks traded daily. The market value of a stock is readily available because of the high frequency of transactions that signal the price to market participants. In contrast, there may only be a few transactions each year that are similar in terms of size, sector, maturity, geography, etc. This asymmetry is further compounded when consider-

ing reporting requirements. Public companies are required to publish quarterly and annual financial reports. What is more, these reports include sections of management discussion, providing deeper insight into the prospects and growth of the companies. However, because many M&A transactions deal with private companies, this information is often not available. For this very reason, investment banks are hired to advise M&A transactions, gather and present company information to potential buyers, and provide a credible reputation to stand behind the company information, thus removing the asymmetry problem. Posing even more of a challenge for empirical research such as this, not all M&A deals are required to disclose the transaction price or valuation multiples. Therefore, particularly when assessing the aggregate market, one must be prudent in selecting relevant variables that are still reliable and consistent despite this lack of information.

When analyzing aggregate data on M&A, four variables reflect the overall market activity: 1) the aggregate value of all disclosed deals, 2) the average size of each deal, 3) the number of deals in each period, and 4) the average valuation multiple of each deal. I argue that the first two are inconsistent metrics due to reporting requirements. Because information is only available on disclosed transactions, the aggregate value of all deals does not represent the entire market and can fluctuate from period to period simply if more or fewer firms disclose deal information. Similarly, the average size of each deal can also fluctuate from period to period as this average size comes from only the sample of deals that are disclosed. For these variables, there is the potential for inconsistency from one period to the next based only on fluctuations in reporting.

The next two variables, however, account for these issues. The total number of M&A transactions represents both disclosed and non-disclosed deals, thus removing the disclosure problem altogether. Looking at the final variable, valuation multiples are disclosed for only a portion of transactions. However, unlike the average deal size, multiples are independent of the size of a company and reflect the real price of the company. If a company with $100 million in revenue is sold for $200 million, the enterprise value (EV) to its revenue, or the revenue multiple, would be 2.0x.[13] If a company with $1 billion in revenue is sold for $2 billion, the revenue multiple would still be 2.0x. Regardless of company size, the average multiple is not distorted. Several

[13]The enterprise value of a company is the price for which the actual company is sold, combining equity and debt less any cash that the company holds.

common multiples are a ratio of EV to revenue, EBIT (earnings before interest and taxes), and EBITDA (earnings before interest, taxes, depreciation, and amortization). Without digging deeply into the accounting for each multiple, this study looks at the EBITDA multiple which is the most commonly used multiple in the investment banking industry. EBITDA indicates a company's operational profitability. In other words, it reflects how much a company can earn with its present assets and operations on the products it manufactures or sells. This multiple is comparable across companies regardless of size, gross margin levels, debt-capital structures, or any one time costs that affect net income. EBITDA is generally considered the truest accounting metric for the health and profitability of a company. Thus, the EBITDA multiple is an excellent pricing metric to determine the value of a company relative both across time and to other companies of varying sizes. When assessing aggregate data, the average EBITDA multiple is a proxy for the average real price of transactions. With these metrics in mind, I now discuss common valuation methods.

Valuation methods can be broken into two main categories: 1) Relative methods that value the company in comparison to similar companies; and 2) Intrinsic methods that value the company based on its own performance. Two types of relative methods are precedent transactions and comparable public companies ("comps"). Precedent transactions look at the financial metrics of similar M&A deals and then apply those multiples and ratios to the target company. Similarly, comps analysis examines the trading multiples of a group of similar public companies and applies them to the financials of the company. In each method, the sample is based on criteria such as industry, financial metrics, geography, and maturity. An analysis will take the multiples of the group of companies, say the EBITDA multiple, and then apply it to the company at hand. As an example, if the average EBITDA multiple of the precedent transactions or comps is 10.0x and the EBITDA of the company is $20 million, the relative methods imply a value of $200 million.

In addition to relative methods, intrinsic methods value a company based solely on its individual financials. Discounted cash flow ("DCF") analysis is the present value of a company's future cash flow, as the real worth of a company is determined by how much cash (income) it can generate in the future. This mirrors the basic asset price valuations discussed previously. A DCF is usually split into two parts. The first component of a DCF is the forecast of a company's free cash

flow over a five to ten year period that is then divided by a discount rate to yield a present value. The most commonly used discount rate is the WACC which is broken into components based on a firm's capital structure. Debt and preferred stock are easy to calculate as they are based on the interest rate of debt or the effective yield of preferred stock. The cost of equity is determined using the Capital Asset Pricing Model ("CAPM") by taking the risk-free rate, i safe, and adding the product of the market risk premium, ϕ, and a company-specific risk-factor, β.[14] Within the CAPM, the risk-free rate is often a 10-year Treasury bond whereas the market risk premium is generally the percentage that stocks are expected to outperform the riskless rate. The CAPM is given by Equation 7:

$$CAPM = i^{safe} + \phi \cdot \beta \tag{7}$$

The three components must be added back together to determine one discount rate, usually calculated by the Weighted Average Cost of Capital ("WACC"). Depicted in Equation 8 below, WACC multiplies each cost by that component's percentage of the total capital structure.

$$\begin{aligned} WACC = Cost\ of\ Equity \cdot \%Equity + Interest\ rate\ \cdot \%Debt \\ + Effective\ yield \cdot \%Preferred\ Stock \end{aligned} \tag{8}$$

The last part of the DCF is a terminal value to reflect the earnings of the company that are generated beyond the projection period. The Gordon Growth Method, a common terminal value, takes the final year of projected free cash flow, multiplied by a projected annual growth rate of the company and then divided by the difference between the discount rate and the growth rate.[15] Adding the discounted free cash flows and the terminal value, the total DCF with a five-year projection period is the following:

[14] A risk-neutral company has a beta of 1. Thus, this company is as risky as the entire market so the risk premium is simply that of the market's risk premium. However, emerging, fast-growth companies may face more risk in getting established. Thus, its beta may be 1.5. Then, investors demand even a higher return on equity to account for this additional risk that is above the market premium.

[15] Note that the annual growth rate of the company must be below the approximate growth rate of the entire economy. If it is not, then the parameter assumes that, in the limit, the company would be larger than the entire economy, which is not a practical assumption.

$$DCF = \frac{FCF_1}{(1+WACC)^1} + ... + \frac{FCF_5}{(1+WACC)^5} + \frac{FCF_5 \cdot (1+g)}{(WACC-g)} \quad (9)$$

The DCF, although one of the most common valuation methods, is highly sensitive to assumptions, particularly for the projected growth of the company, the beta risk-factor, and the terminal value. This creates asymmetric information where the seller will inevitably have more information than the buyer. Adverse selection may even arise where all sellers, whether performing well or not, will present favorable assumptions as buyers do not have the same insight to whether or not such projections are realistic and probable. For this reason, transactions rely on the credibility of investment banks and the use of multiple valuation methods to minimize asymmetric information.

Another intrinsic method is the leveraged buyout model ("LBO"), a more advanced valuation method that is relevant to acquisitions that involve a large amount of debt such as private equity acquisitions. An LBO works for three key reasons:

1. Up-front cash payment on the part of the acquirer is reduced by issuing debt;

2. The cash flows generated by the company can be used to pay down the debt;

3. The return on the future re-sale totals the initial funds spent, the amount of debt paid down, and any additional value from the company's growth.[16]

Briefly, I illustrate these three points in an example. Consider a private equity firm that acquires a $300 million portfolio company with $100 million of its own equity and finances the rest of the acquisition by issuing $200 million in debt. Over the course of several years, the investment in the company allows it to grow while also using its profits to pay down the $200 million in debt. Then, the private equity firm can re-sell the company at a higher price, earning a substantial return

[16]To understand this concept of leverage, literally picture a lever that has a shorter side and a longer side separated by a fulcrum. The larger side of course allows for greater force to be created. Likewise, the larger amount of debt allows for a greater return from a smaller portion of equity.

on the original equity investment. Although highly stylized, this illustrates how the more advanced LBO can yield above-market returns, as found in the Harris et al. study.

By applying the Asset Price Channel from the previous section to M&A activity, the potential effects of monetary policy are very similar to those of stock prices. For simplicity, let's only look at the DCF as an example. If the Fed raises the interest rate, the DCF could lower for several reasons. This could increase the interest rate on debt and i^{safe}.[17] What is more, this increase in the interest rates may discourage borrowing by the firm to fund additional investment projects. As a result, the projected annual growth in cash flows may decrease. In addition to these two issues, the WACC may be affected as well. The monetary policy shock is likely to make output more volatile, including the risk of the entire market and the firm, causing β to increase. A higher β results in a higher WACC. All of these components would result in a lower valuation of a firm. This DCF analysis illustrates the Asset Price Channel. If this theory holds, then one would expect the data to show that an increase in the interest rate by the Fed leads to a decrease in the number of M&A transactions and in the average EBITDA multiple.

IV. Data

The data considered in this study is broken into three groups: 1) M&A metrics, 2) interest rates, and 3) Taylor rule variables. The M&A data was made available by Dealogic, a research firm that specializes in providing information to investment banks and brokerage firms. The data gathered by Dealogic covers over 99% of all M&A activity across the globe. This dataset includes quarterly data from 2003 through 2013 on the total number of transactions in each period, the total value of all disclosed transactions, the average deal value of disclosed transactions, and average EBITDA multiple of disclosed transactions.[18]

As discussed in the previous M&A sections, the analysis below does not include the total value of all disclosed transactions or the average deal value of disclosed transactions because of inconsistencies

[17] This is a stylized example. Again, the Fed raising the short-term federal funds rate would realistically not have this one-to-one effect on debt interest rates and risk-free rates. However, this provides a high-level analysis of how the theory would affect the prices of M&A transactions.

[18] To be more precise, this data only goes through Q2 of 2013. Also, the number of disclosed and non-disclosed transactions in each period was not available.

in the sample of what deals are disclosed from one period to the next. Therefore, I focus on the number of total transactions which represents disclosed and non-disclosed deals and the average EBITDA multiple which is consistent regardless of sampling. Over this time period, the average EBITDA multiple was 11.12x and the average number of transactions per quarter was 2,793.

Below, Figure 1 displays the quarterly data for average EBITDA and number of transactions from 2003:Q1 to 2013:Q2. First, notice the steep decline in both price and activity in 2008 and 2009 as the financial crisis created great uncertainty and panic in the M&A market, causing investment activity to stagnate. A rebound followed that eventually led to record highs in number of transactions in 2011 and 2012. Also, this time series illustration shows the close relationship between these variables. Like any market, when the demand goes up and the quantity of transactions increases, this is accompanied by an increase in price. The M&A market is no different as the number of transactions and the average EBITDA multiple trend together.

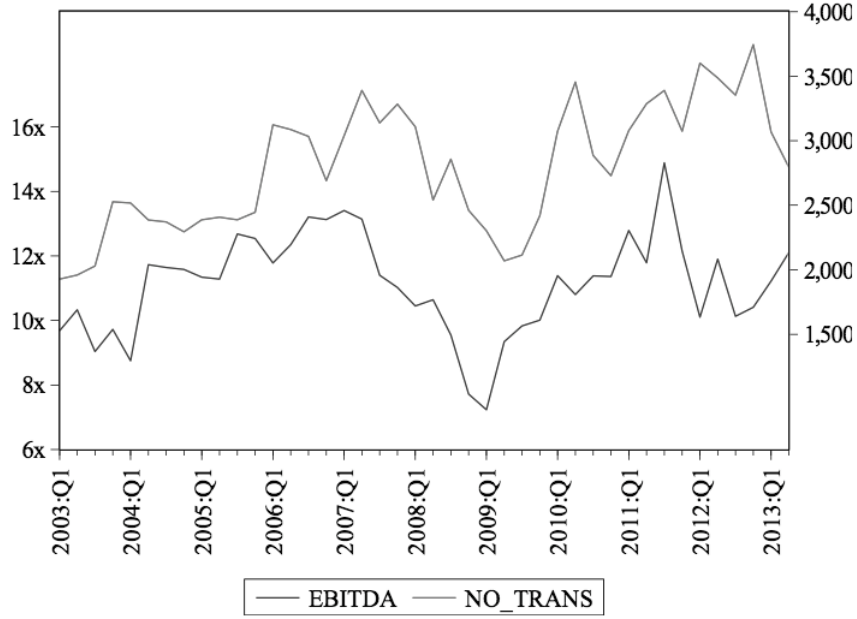

Figure 1: Average EBITDA and Number of Transactions from 2003:Q1 to 2013:Q2

The remaining variables were gathered from the Federal Reserve

Economic Data ("FRED"). In selecting an interest rate, the choice consistent with previous empirical studies is the federal funds rate ("FFR"). As discussed previously, the FFR is subject to a zero lower bound which was reached in 2009. The data on this will depict inaccurate results from 2009 to 2013 because the linear model would no longer hold. Thus, the dataset is cut-off in 2008. Because of this limited timeframe, this empirical study also includes the ten-year Treasury rate. As the study will show later, this still provides a consistent depiction of monetary policy transmission when modeling the Taylor rule. Because the ten-year rate never reaches its zero lower bound, this second interest rate allows the empirical analysis to consider the full MA dataset from 2003 through 2013. What is more, much of recent monetary policy actions have aimed to also affect long-term interest rates. Even from a monetary policy perspective beyond logistics with the data, the ten-year rate is natural to include in this analysis alongside the FFR.

For both the FFR and the ten-year, the end of period values are used, implying that the Federal Reserve responds to the macroeconomic variables in that current period whereas a change in the interest rate is likely to have a delayed effect on the macroeconomic variables. Thus, although the end of period is used for the interest rates, the average of the quarterly period is used for the Taylor rule variables. Finally, in order to analyze alongside the following Taylor rule variables, the data for both interest rates begin in 1990 with the FFR ending in 2008 and the ten-year ending in 2013. From 1990 through 2008, the average FFR was 4.23%. From 1990 through 2013, the average ten-year rate was 5.05%. Figure 2 highlights several key points concerning the FFR and the ten-year rates. First, this shows the ZLB that the FFR reached in late 2008, a bound that it has stayed at through 2013.

Secondly, this time series graph illustrates that the ten-year rate is a good proxy for the FFR as the two interest rates move together, reaching peaks and troughs at roughly the same time periods. The FFR moves more extremely, yet more smoothly than the ten-year rate. Because it is controlled by the Fed, the FFR changes in a disciplined, gradual manner whereas the ten-year rate faces more frequent fluctuations due to other market forces. However, the FFR also moves more extremely, particularly for cuts in the FFR. This is evident from 1992 to 1993, 2001 to 2004, and from 2008 to the present. In each case, the Fed cut rates aggressively in efforts to adequately respond to a slumping

economy. Even though the ten-year rate decreases during these periods, the troughs are less severe.[19]

The final group of variables are the Taylor rule parameters which includes real GDP and inflation. The metric for GDP is the seasonally adjusted, quarterly average of the natural log of billions of chained 2009 dollars. Similarly, inflation is measured by the quarterly average of the natural log of the seasonally adjusted personal consumption index. The inflation rate is simply the difference of these natural logs. Again, the data for both variables is quarterly from 1990 through 2013. The average log of GDP and of the price level during this time period was 9.4 and 4.5, respectively. Figure 3 displays the difference of natural log for GDP and of the price level from 1990 to 2013.[20]

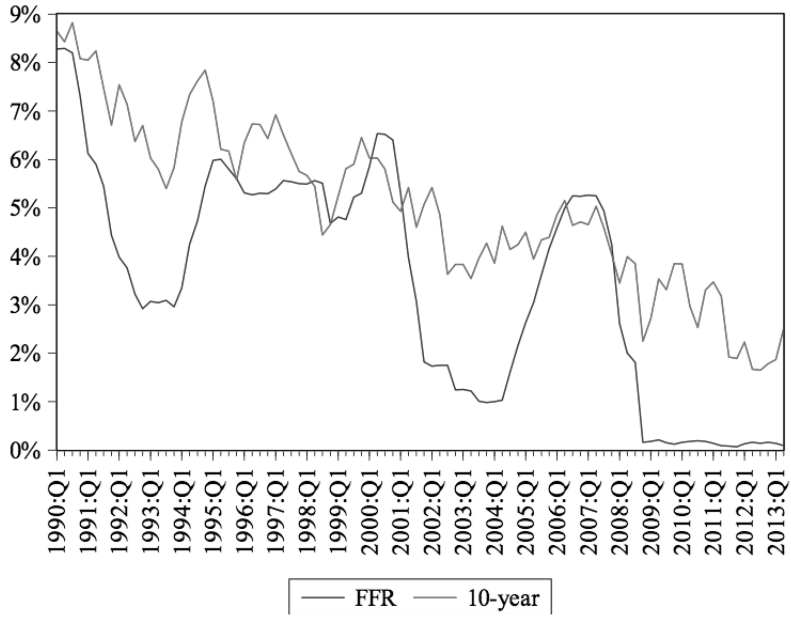

Figure 2: Federal Funds Rate and 10-year Treasury Rate from 1990:Q1 to 2013:Q2

Inflation has been remarkably stable over this time period, remaining steady around 0.5% per quarterly, or roughly 2% annually. This

[19]Recall that the ten-year rate will decrease (although less sharply) with cuts in the FFR because of the Expectations Hypothesis.

[20]In the actual model, the natural logs are used; however, the difference of natural logs better illustrates the GDP growth rate and the inflation rate.

reflects the Fed's success in maintaining its target inflation rate. The one noticeable exception is the sharp deflation of 1.4% in 2008:Q4, which was in the heart of the Great Recession. Secondly, the late 1990s saw steady GDP growth as the quarterly growth rate increases significantly from 1996 through 2000. This line also shows the true impact of the Great Recession on the economy where GDP growth decreases severely and is negative for most of 2007 to 2010.

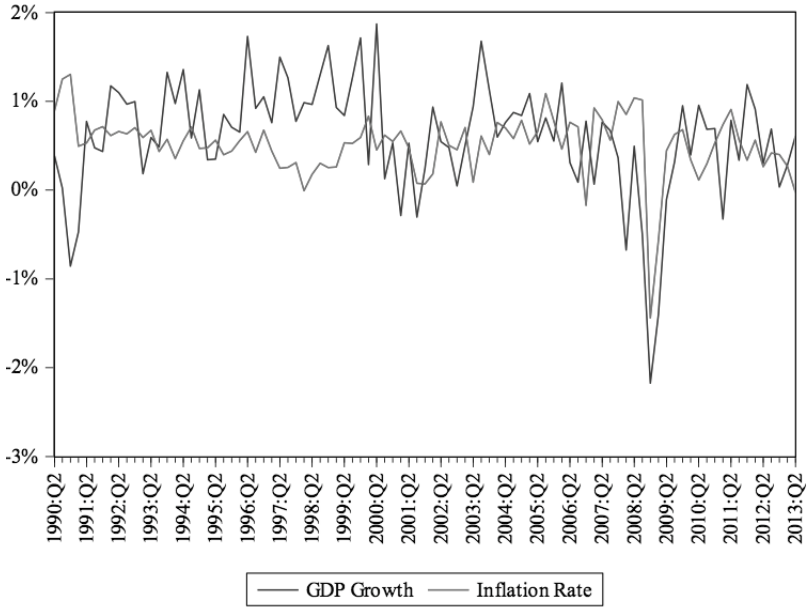

Figure 3: Quarterly GDP Growth Rate and Inflation rate from 1990:Q2 to 2013:Q2 [21]

Below is a table of all the descriptive statistics of all the variables. EBITDA is presented as a multiple representing the total value of the transaction divided by the EBITDA. Also, the minimum of the FFR is 0.16%, which occurs in 2008, signaling the ZLB. Finally, as mentioned above, both GDP and inflation are reported as the differences of natural logs, which is the quarterly growth rate. The levels of GDP and PCE are not of importance, but only the natural logs which reflect the GDP growth rate and the inflation rate. In the actual model, the natural log is used rather than the difference in natural logs.

Table 1: Descriptive Statistics

Variable	Average	Minimum	Maximum	St. Dev.
EBITDA	11.12x	7.23x	14.89x	1.55x
Number of Transactions	2793	1927	3745	488
FFR	4.23%	0.16%	8.29%	1.90%
Ten-year	5.05%	1.65%	8.82%	1.76%
GDP growth rate	0.60%	-2.18%	1.87%	0.64%
Inflation rate	0.51%	-1.44%	1.30%	0.35%

Figure 4: Descriptive Statistics

V. Method

A vector autoregression ("VAR") is an estimation technique that captures linear interdependence among multiple time series by including the lags of variables. In such a model, each variable has its own equation that includes its own lags and the lags of other variables in a model. Together, the entire VAR model has simultaneous equations that provide a model for how variables affect each other intertemporally. Bernanke and Mihov (1998) famously argue that such VAR-based methods can be applied to monetary policy because VAR innovations to the FFR can be interpreted as innovations in the Fed's policy. Thus, a VAR model can be created using the current FFR and its lags alongside the current and lagged values of other macroeconomic variables. This allows empirical analysis to then determine the effects of innovations in monetary policy on other variables. In this study, because the M&A data overlaps the monetary interest rates, GDP, and inflation for a limited sample, I am using a modified VAR technique. Think of this model as establishing a Taylor rule using inflation and real GDP. The residuals in this equation are exogenous monetary shocks, that is, deviations from the Taylor rule. A second step then inputs these shocks – the residuals – into another VAR with the MA data.

In the results below, I include a VAR of the FFR and the ten-year rate with the Taylor rule variables. This illustrates the basics of the VAR technique and the intertemporal relationships between monetary policy innovations and macroeconomic variables. It is also important

to include a word on the ordering of variables. By including the interest rate last, it suggests that monetary policy responds immediately to the current levels of GDP and inflation whereas the effects of the current interest rate really only have lagged effects on the macroeconomy. [22] When ordering a VAR, an implicit assumption is being made about the timing of the intertemporal responses. Together, Equations 10-12 create a VAR model portraying a form of the Taylor rule

$$\begin{aligned} GDP_q = \beta + \beta_1 \cdot GDP_{(q-1)} + \beta_2 \cdot GDP_{(q-2)} + \beta_3 \cdot GDP_{(q-3)} \\ + \beta_4 \cdot GDP_{(q-4)} + \beta_5 \cdot Inflation_q + \beta_6 \cdot Inflation_{(q-1)} + \beta_7 \cdot Inflation_{(q-2)} \\ + \beta_8 \cdot Inflation_{(q-3)} + \beta_9 \cdot Inflation_{(q-4)} + \beta_{10} \cdot Interest\ rate_q \\ + \beta_{11} \cdot Interest\ rate_{(q-1)} + \beta_{12} \cdot Interestrate_{(q-2)} + \beta_{13} \cdot Interest\ rate_{(q-3)} \\ + \beta_{14} \cdot Interest\ rate_{(q-4)} \end{aligned} \quad (10)$$

$$\begin{aligned} Inflation_q = \beta + \beta_1 \cdot Inflation_{(q-1)} + \beta_2 \cdot Inflation_{(q-2)} \\ + \beta_3 \cdot Inflation_{(q-3)} + \beta_4 \cdot Inflation_{(q-4)} + \beta_5 \cdot GDP_q \\ + \beta_6 \cdot GDP_{(q-1)} + \beta_7 \cdot GDP_{(q-2)} + \beta_8 \cdot GDP_{(q-3)} + \beta_9 \cdot GDP_{(q-4)} \\ + \beta_{10} \cdot Interest\ rate_q + \beta_{11} \cdot Interest\ rate_{(q-1)} + \beta_{12} \cdot Interestrate_{(q-2)} \\ + \beta_{13} \cdot Interest\ rate_{(q-3)} + \beta_{14} \cdot Interest\ rate_{(q-4)} \end{aligned} \quad (11)$$

$$\begin{aligned} Interest\ rate_q = \beta + \beta_1 \cdot Interest\ rate_{(q-1)} + \beta_2 \cdot Interest\ rate_{(q-2)} \\ + \beta_3 \cdot Interest\ rate_{(q-3)} + \beta_4 \cdot Interest\ rate_{(q-4)} + \beta_5 \cdot GDP_q \\ + \beta_6 \cdot GDP_{(q-1)} + \beta_7 \cdot GDP_{(q-2)} + \beta_8 \cdot GDP_{(q-3)} + \beta_9 \cdot GDP_{(q-4)} \\ + \beta_{10} \cdot Inflation_q + \beta_{11} \cdot Inflation_{(q-1)} + \beta_{12} \cdot Inflation_{(q-2)} \\ + \beta_{13} \cdot Inflation_{(q-3)} + \beta_{14} \cdot Inflation_{(q-4)} \end{aligned} \quad (12)$$

In an ideal case, one would run the same VAR above while including a fourth variable that measures MA activity. However, given

[22] This means that a statistical software program will order Equations 10-12 in that order. The ordering of the coefficients within each equation is not of concern for this timing assumption.

the limited data set with the ZLB, I employ the two-step VAR technique described above to assess the effects of monetary policy shocks on MA activity. Using Equations 10-12 for both the FFR and the ten-year Treasury rate, I find the fitted values for the interest rate given the parameters of the model. The residuals of the interest rates from the VAR model can then be calculated using Equation 13 where i is the actual value of the interest rate, $\hat{i}$ is the estimated value of the interest rate, and e_i is the residual.

$$e_i = i - \hat{i} \tag{13}$$

The residuals reflect monetary policy that differs from the Taylor rule, or shocks to monetary policy. By using this historical data in this way, the model extracts exogenous shocks in monetary policy for the period covering the M&A data.

The next step in this technique is to take these residuals and create another VAR model, this time using the current and lagged values of the residual shocks and the M&A data.[23] This model is given by Equation 14:

$$\begin{aligned} M\&A\ Metric_q = \\ \beta + \beta_1 \cdot M\&A\ Metric_{(q-1)} + \beta_2 \cdot M\&A\ Metric_{(q-2)} + \\ \beta_3 \cdot M\&A\ Metric_{(q-3)} + \beta_4 \cdot M\&A\ Metric_{(q-4)} + \beta_5 \cdot e_{(i,q)} \\ + \beta_6 \cdot e_{(i,q-1)} + \beta_7 \cdot e_{(i,q-2)} + \beta_8 \cdot e_{(i,q-3)} + \beta_9 \cdot e_{(i,q-4)} \end{aligned} \tag{14}$$

This VAR model will then allow for the same sort of impulse response functions that were discussed previously for illustrating the Taylor rule. However, in this case, the impulse is an actual change in the residual, or monetary policy shock. If the Asset Price Channel holds, M&A activity will decrease when the interest rate increases. Thus, a positive impulse to the residual would cause the average EBITDA multiple and the number of transactions to decrease.

[23] For consistency, I again use four lags of the data. Also, the interest rate shock is again ordered second as monetary policy would not respond immediately to M&A activity whereas the asset-price channel suggests that M&A asset prices would respond immediately.

VI. Results

From Equations 10-12 the first VARs presented are linear, inertial Taylor rules using the lagged and contemporaneous values of the interest rate, GDP, and the price level.[24] The first and primary purpose of this VAR is to take the residuals between the fitted FFR values and the actual FFR values. Applying Equation 13, this creates the exogenous shocks, or innovations, in the FFR that cannot be explained by the model. Over the period from 2003 to 2008, these residuals serve as the monetary policy shocks that will be used to analyze M&A activity. This VAR has an F-statistic of 120.35 and an R-squared value is 0.967. Next, I repeat this process using the 10-year rate in a VAR alongside GDP and inflation. In this VAR, the R-square is even stronger with a value of 0.999, and the F-statistic is 8102.57. The residuals are thus statistically significant and can be used as proxies for exogenous innovations in monetary policy.

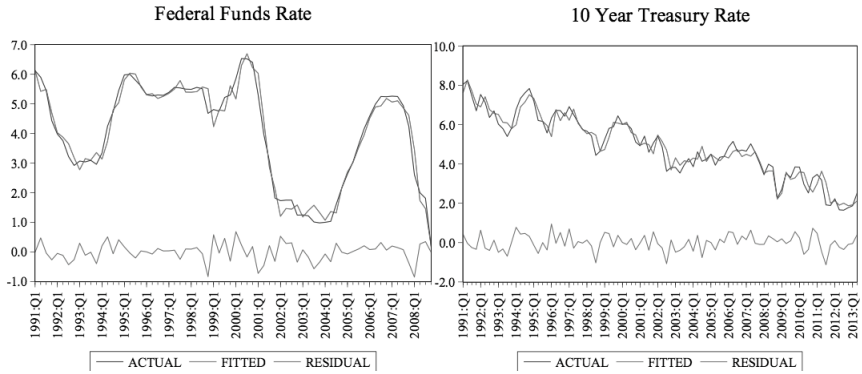

Figure 5: Actual Interest Rate vs. Taylor-Rule Estimation

Another way to confirm the validity of this VAR Taylor rule is to compare the actual interest rate values to the fitted values from the VARs. As Figure 5 illustrates, the fitted values mirror the actual values very closely. The difference between the actual and fitted values are

[24]Note that earlier I described the GDP growth rate and inflation rate. From here on out, the terms GDP and inflation refer to the actual levels of output and prices, respectively. Also note that trends in these two variables are still captured by using levels because of the nature of a VAR which incorporates lagged values, thus structurally incorporating trends.

movements in the interest rate where the Fed is not responding to output and inflation, representing shocks that can be placed into a second VAR with the M&A data.

Equation 14 is modeled with the number of transactions responding to the FFR shocks, or residuals from the above graphs. The R-squared is 0.67 with an F-statistic of only 2.74. This is in larger part due to the limited data range from 2003 to 2008 that is further restricted by the inclusion of lagged values. Figure 5 illustrates the simulation of a shock of one standard deviation to the FFR residual in this VAR model on the number of transactions. This simulates a roughly exogenous 30 basis-point increase in the FFR. The response of the number of transactions has an initial positive increase of roughly fifty to two hundred transaction per quarter. The accumulated response levels off at roughly 575 transactions after six quarters. Multiplying the quarterly average by six, this number of transactions is a 3.4% increase in the number of transactions. This is in the direction opposite of what would be predicted by the Asset Price Channel. Most importantly, the standard error bands in the graph indicate that the response is not statistically significant.[25] This not only provides evidence against the Asset Price Channel, but it also contradicts the hypothesis.

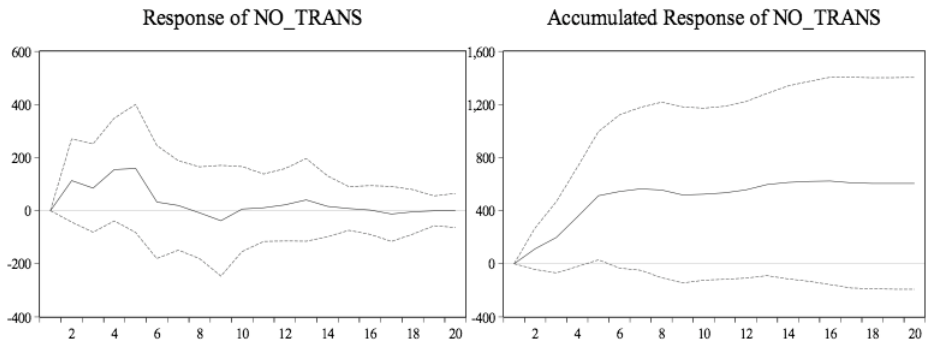

Figure 6: Response of Number of Transactions to a One S.D. Shock in the FFR Residual $\pm 2S.E.$

This process is repeated using the FFR residuals and EBITDA. The R-squared is 0.67 with an F-statistic of 2.82. As Figure 7 highlights, the EBTIDA response to a simulated one standard deviation shock to

[25]The red bands, as with all of these illustrations, reflect the values plus/minus two analytic standard errors.

the FFR residual is not statistically significant. Only a limited portion of this projection period is relevant. For example, in quarter 14, the accumulated response is roughly 4x which is not even a realistic response given that the average EBITDA is only 11x. This suggests that this particular model may not be reflecting the relationship correctly. Again, I stress that this is in large part be due to the limited data as this only covers 2003 to 2008 before the FFR reached the zero lower bound. Over the course of the first three years, the accumulated response of EBITDA fluctuates between 1 and 3x. 2x is roughly 20% of the average EBITDA so the magnitude of the response is considerable given the shock to the FFR is only 40 basis-points. Given the volatility of both EBITDA, the standard error bands confirm that this is not a statistically significant impulse response. It remains that there is no evidence to support the Asset Price Channel and actually limited evidence to contradict the explanation.

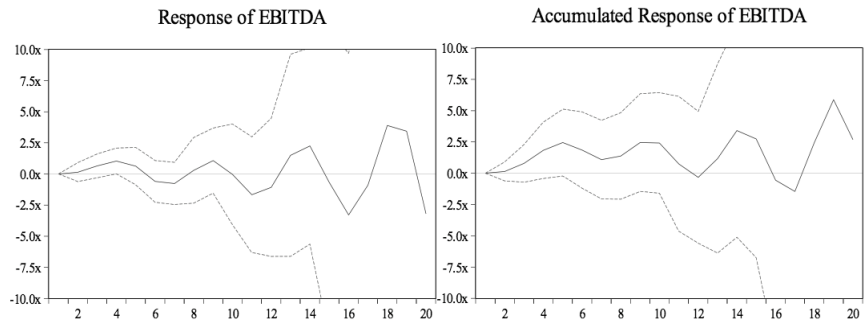

Figure 7: Response of EBITDA to a One S.D. Shock in the FFR Residual $\pm 2S.E.$

The above two VAR models are replicated using the residuals of the ten-year rate with an approximate 40 basis-points shock. Beginning with the number of transactions, this VAR has an R-squared of 0.60 with a stronger F-statistic of 5.4. The response of the number of transactions is not statistically significant, but is again positive. Looking at the accumulated response in Figure 8, the response flattens out around two hundred transactions by the end of the first projected year, or roughly 2% annually. A continuing theme exists in this VAR setup with no evidence supporting the Asset Price Channel and even slight

evidence contradicting it.

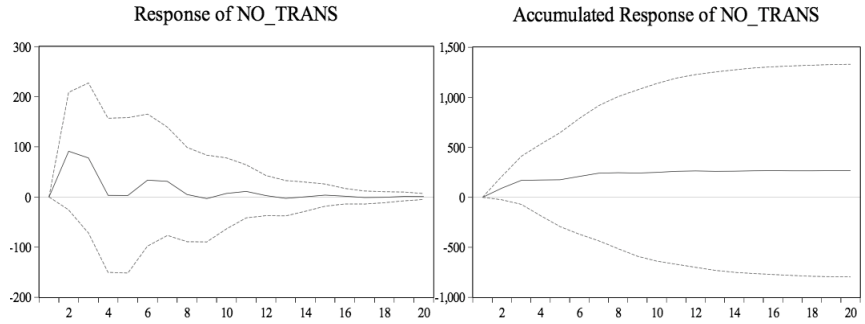

Figure 8: Response of Number of Transactions to a One S.D. Shock in the 10-year Rate Residual $\pm 2S.E.$

The final VAR model repeats the process using EBITDA with the residuals of the ten-year rate. This time, the R-squared is only 0.48 with an F-statistic of 3.34. Figure 9 illustrates the accumulated response of EBITDA to an approximate 40 basis-points shock to the ten-year rate residual. The response does not statistically differ from zero and peaks at 0.4x, or roughly 3.5%, in the second projected year. Like the other VAR models, this model provides no evidence in support of the Asset Price Channel and limited evidence against it.

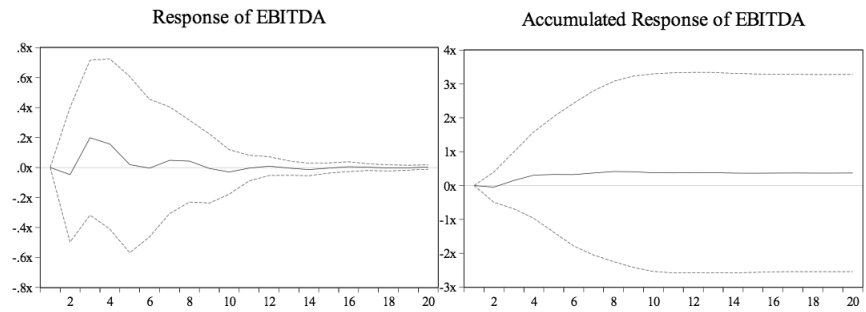

Figure 9: Response of EBITDA to a One S.D. Shock in the 10-year Rate Residual $\pm 2S.E.$

An alternative explanation places GDP as the primary driver of movements in asset prices. I hypothesize that the main concern of both investors and bankers is inevitably output – the production of

the firm, of its industry, and of the entire economy. Thus, a positive shock to GDP should result in increases in M&A prices and activity. By extracting the GDP residuals, exogenous shocks to GDP are identified that can then be modeled with the M&A data to determine the effect of output on M&A activity. I repeat the previous process by running Equations 10-14 using GDP, inflation, and the ten-year rate.[26] This time, Equations 13 and 14 take the residuals of GDP to identify GDP shocks that are then modeled in a VAR with the M&A metrics.

In the VAR with GDP residuals and the number of transactions, a 0.6% quarterly shock to GDP has a statistically significant shock on the number of transactions. The accumulated response reaches a level around 900 transactions, or roughly 8% of the annual average number of transactions. This is strong evidence that GDP explains movements in M&A activity.

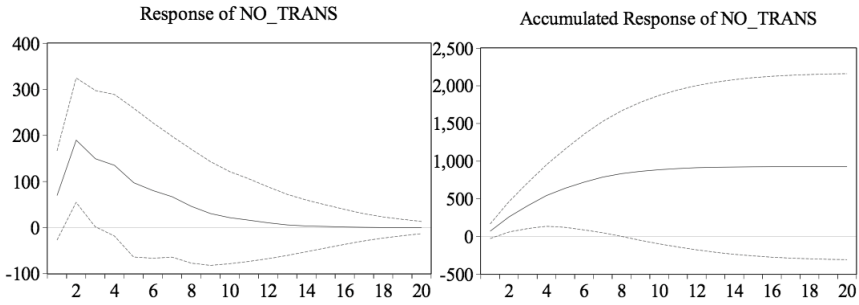

Figure 10: Response of Number of Transactions to a One S.D. Shock in the GDP Residual $\pm 2S.E.$

In the VAR with GDP residuals and the EBITDA multiple, a shock to GDP again leads to a positive response in the M&A metric. The GDP shock is approximately 0.5%. Despite being statistically insignificant, the magnitude of the shock reaches 1.4x, or roughly 12.5% of the average EBITDA multiple. This impulse response function is additional evidence supporting the explanation that GDP is a fundamental driver of movements in M&A activity.

[26] I use the ten-year interest rate instead of the VAR so as to use the entire dataset with the M&A metrics. In the impulse response functions, I order inflation before GDP, suggesting that inflation contemporaneously respond to GDP, but GDP does not contemporaneously respond to inflation. This depicts a model where prices are sticky. For robustness, I re-ran the model ordering GDP before inflation and the results were qualitatively the same both in the Taylor rule VAR and with the M&A data.

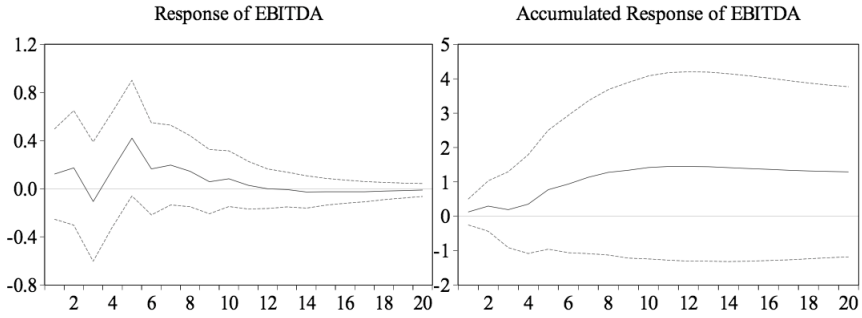

Figure 11: Response of EBITDA to a One S.D. Shock in the GDP Residual $\pm 2S.E.$

VII. Conclusion

When considering this alternative explanation, there is strong evidence in support of GDP as the primary explanation for movements in M&A prices and activity. A shock to GDP produces positive responses in both EBITDA and the number of transactions. I conclude that output is ultimately the primary driver of movements in the asset prices of M&A transactions. This is not a surprising result. At its fundamental level, the output of the firm, its industry, and the broader market drives M&A prices. Despite the persuasiveness of the Asset Price Channel, the data does not support this theory, but instead presents a simpler picture of movements in asset prices dependent solely on output.

This empirical study is an important addition to the monetary policy literature by considering a new asset class in M&A activity. Unlike the studies analyzing monetary policy with stock prices and housing prices, the Asset Price Channel does not hold with the number of M&A transactions and the average EBITDA multiple, reflecting both M&A activity and prices. Rather, the critical component in explaining movements in M&A activity is output. Although this empirical study does not find evidence of a relationship with monetary policy, it is still conceivable that an implicit relationship exists between monetary policy influencing output which then influences the M&A market. Regardless, this article does not find any direct relationship between monetary policy and M&A activity and therefore concludes that the Asset Price Channel does not hold. This study, then, is an important expansion of the literature and provides further understand-

ing of the relationship between monetary policy and asset prices in the M&A market.

References

[1] Ball, Laurence M. 2012. Money, Banking, and Financial Markets. *New York: Worth Publishers.*

[2] Bernanke, Ben and Ilian Mihov. 1995. "Measuring Monetary Policy." *Quarterly Journal of Economics. 113.3: 869-902.*

[3] Bernanke, Ben and Kenneth Kuttner. 2005. "What Explains the Stock Market's Reaction to Federal Reserve Policy?" *The Journal of Finance.* 60.3: 1221-1257.

[4] Bernanke, Ben and Mark Gertler. 2001. "Should Central Banks Respond to Movements in Asset Prices?" *The American Economic Review.* 91.2: 253-257.

[5] Bernanke, Ben. 2010. "Monetary Policy and the Housing Bubble." Presented at the Annual Meeting of the American Economic Association. *Board of Governors of the Federal Reserve System.* Atlanta, Georgia, January 3.

[6] Bernanke, Ben. 2002. "On Milton Friedman's Ninetieth Birthday." Presented at the Conference to Honor Milton Friedman. *University of Chicago.* Chicago, Illinois, November 8.

[7] Bohl, Martin, Pierre Siklos, and Thomas Werner. 2007. "Do central banks react to the stock market? The case of the Bundesbank." *Journal of Banking and Finance.* 31.2:719-733.

[8] Bordo, Michael and Olivier Jeanne. 2002. "Monetary Policy and Asset Prices: Does 'Benign Neglect' Make Sense?" *International Finance.* 5.2: 139-164.

[9] Bullard, James. 2013. "An Update on the Tapering Debate." *Federal Reserve Bank of St. Louis*, August 15.

[10] Bullard, James. 2007. "Seven faces of" the peril." *Federal Reserve Bank of St. Louis Review*. 339-352.

[11] Carlstrom, Charles and Timothy Fuerst. 2007. "Asset Prices, Nominal Rigidities, and Monetary Policy." *Review of Economic Dynamics.* 10: 256-275.

[12] Carlstrom, Charles and Timothy Fuerst. 2012. "Gaps versus Growth Rates in the Taylor rule." *Federal Reserve Bank of Cleveland*, October.

[13] Cecchetti, Stephen, et al. 2000. "Asset prices and Central Bank Policy." Paper presented at *The Geneva Report on the World Economy No. 2. Geneva, Switzerland*, May.

[14] Davig, Troy and Eric Leeper. 2007. "Generalizing the Taylor Principle." *The American Economic Review.* 97.3: 607-635.

[15] "DCF Questions Answers." 2012. Breaking Into Wall Street: *Investment Banking Interview Guide.*

[16] "Equity Value and Enterprise Value Questions Answers." 2012. *Breaking Into Wall Street: Investment Banking Interview Guide.*

[17] Erler, Alexander, Christian Drescher, and Damir Krizanac. 2013. "The Fed's TRAP: A Taylor-Type Rule with Asset Prices." *Journal of Economics and Finance.* 37.1: 136-149.

[18] Filardo, Andrew. 2000. "Monetary Policy and Asset Prices." *Economic Review – Federal Reserve Bank of Kansas City.* 85.3: 11-38.

[19] Gilchrist, Simon and John Leahy. 2002. "Monetary Policy and Asset Prices." *Journal of Monetary Economics.* 49.1: 75-97.

[20] Goodhart, Charles and Boris Hofmann. 2000. "Asset Prices and the Conduct of Monetary Policy." Presented at *Sveriges Riksbank and Stockholm School of Economics Conference on Asset Markets and Monetary Policy*. Stockholm, Sweden, June.

[21] Harris, Robert, et al. 2013. "Private Equity Performance: What do we know?" *National Bureau of Economic Research.* Forthcoming in Journal of Finance.

[22] Henderson, Nell. 2005. "Bernanke: There's No Housing Bubble to Bust." *Washington Post*, October 27.

[23] Iacoviello, Matteo. 2005. "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle." *The American Economic Review.* 95.3: 739-764.

[24] Ida, Daisuke. 2011. "Monetary Policy and Asset Prices in an Open Economy." *North American Journal of Economics and Finance.* 22.2: 102-117.

[25] Laeven, Luc and Hui Tong. 2012. "US Monetary Shocks and Global Stock Prices." *Journal of Financial Intermediation.* 21.3: 530-547.

[26] "LBO Model Questions Answers." 2012. *Breaking Into Wall Street: Investment Banking Interview Guide.*

[27] Rigobon, Roberto and Brian Sack. 2003. "Measuring the Reaction of Monetary Policy to the Stock Market." *The Quarterly Journal of Economics.* 118.2: 639-669.

[28] Rigobon, Roberto and Brian Sack 2004. "The Impact of Monetary Policy on Asset Prices." *Journal of Monetary Economics.* 51.8: 1553-1575.

[29] Taylor, John. 2007. "Housing and Monetary Policy." *Federal Reserve Bank of Kansas City.* 463-476.

[30] Taylor, John. 1993. "Discretion versus Policy Rules in Practice." *Carnegie-Rochester Conference Series on Public Policy.* 39: 195-214.

[31] "Valuation Questions Answers." 2012. *Breaking Into Wall Street: Investment Banking Interview Guide.*

[32] Wongswan, Jon. 2009. "The Response of Global Equity Indexes to U.S. Monetary Policy Announcements." *Journal of International Money and Finance.* 28.2: 344-365.

The Effect of Crime on Achievement

The differential effect of violent and non-violent crimes on achievement in high schools

Colin Rohm & Alex Mok

Abstract

This paper examines how the different forms of crime, violent and non-violent, affect the academic achievement of students scoring in the bottom 15% of standardized tests. Though funding for violent crime prevention may be justified based on the significant impact it has on students, our paper asks the question "can the same case be made to justify drug use prevention programs?"

I. Introduction & Background

According to the *Indicators of School Crime and Safety: 2010* report published by the National Center for Educational Statistics (NCES), there were approximately 1.2 million victims of non-fatal crimes within school bounds in 2008. Of these, there were 629,800 counts of simple assault, rape, robbery and other "violent" and "non-violent" crimes. These incidents have observable and noteworthy consequences; victims of crimes are known to avoid after school activities and certain locations at school, or skip class entirely - all behaviors which impede a student's academic achievement (U.S. Department of Justice). In addition to the victims, the rest of the school body is harmed by an environment with crime as other students and teachers fear criminal actions against them (Hull 2000).

In an effort to combat these issues, federal and state governments spend millions of dollars on crime prevention measures such as metal detectors, security forces, and additional training for staff. In the 2008-2009 school year, the New York City Department of Education, responsible for the largest school district in the United States, reported school expenditures of $287,384 on school safety services and $37,856 on drug prevention programs.

Is this spending, however, efficient? This paper examines the relationships between crime and student achievement. In particular, we explore how crime may affect those students who score into the bottom 15% of standardized test scores. We focus on this population as

it is the one of the groups that receives particular focus from the No Child Left Behind Act as well as being a direct benefactor of the crime prevention spending mentioned previously.

As will be shown in the review of literature, the majority of previous studies focus on the negative impact of more dramatic, violent crimes. These large and negative impacts are often used to justify the funding of crime prevention programs. There is, however, less to no attention paid to non-violent offenses. In performing a quantitative analysis of violent and non-violent crimes, our paper contributes to the larger body of knowledge by studying the effect of non-violent crimes on student achievement.

We confirm previous findings that violent crimes have significantly negative correlation with student achievement, thus providing additional evidence for justifying spending on violent crime preventions. Non-violent crimes, however, are found to have a statistically insignificant relationship with achievement, making funding for non-violent crime prevention programs less efficient from a student-impact viewpoint. We begin with a review of crime in schools in the current literature. We then present our data and regression model and results; this is followed by a discussion of our findings and possible policy implications.

II. Review of Literature

Past research has found that students affected by crime suffer academically (MacMillan and Hagan 2004; Wei and Williams 2004). These students also have poorer attendance rates (Ringwalt, Ennett, Johnson 2003). Additionally, criminal activity disrupts the general atmosphere of schools, negatively affecting staff and the greater community (Henry 2000).

Henry (2000) also points out that school violence is an issue that cannot be viewed properly from a narrow perspective that examines only interpersonal violence; it is the result of many forces from both within and without the school grounds. Broader social issues, such as poverty, social exclusion, and economic inequality are major contributors to school violence (Kramer 2000). The qualities of the surrounding neighborhood, such as levels of crime and wealth, have also been found to affect school crime rates – and thus student achievement (Lee and Madyun 2009; Juvonan, Nishma, and Graham 2000).

While these studies have found crime to adversely affect academics, they fail to distinguish between violent (shootings, armed robberies, etc.) and non-violent (drug and alcohol possession, vandalism, etc.) crimes, or focus solely on violent crimes. Our subsequent analysis explores this gap in the literature by explicitly comparing the differential impacts of violent and non-violent crime on students.

III. Data Source

Our primary source of data for this study is "The School Survey on Crime and Safety" (SSOCS) as published by the National Center for Education Statistics. The SSOCS is a survey on over 3,500 public elementary and secondary schools, focusing on school crime, discipline, disorder, programs, and policies that ran on all even years except 2002 between 2000 and 2008.

This data set is unique from others performed in the past because of its repeated observations on even numbered years; the study is currently processing its fifth set of data and allows us to track changes over time. This makes the SSOCS an excellent source of data while controlling for various time trends, allowing our analysis of crime to be more accurate than those using other data sets that do not divide crimes into specific categories.

One concerning factor regarding this data set is that it is a repeated cross-section of the nation and is not longitudinal. Longitudinal data would allow us to remove time trends and examine the specific change in crime within schools due to policy changes. Consequently, we will only be looking at specific correlations between crimes and achievement.

The nature of several elements in the survey also raises some concerns. The survey includes over thirty questions with multiple parts, but many are qualitative in nature, and responses could vary based upon how the responding principal feels on any given day, or if they recently had problems with specific areas addressed in the survey.

	Observations	Mean	Standard Deviation	Min, Max
Incidents 03	5544	46.39286	75.52111	0,2142
Violent Incidents 03	5544	30.62518	63.74942	0,2139
Rapes 03	5544	0.024892	0.2091903	0,5
Sexual Batteries 03	5544	0.172078	1.46877	0,50
Robberies with a Weapon 03	5544	0.04329	0.8051801	0,35
Robberies without a Weapon 03	5544	0.363997	1.902336	0,41
Attacks with a weapon 03	5544	0.250722	2.595097	0,97
Attacks without a weapon 03	5544	17.44697	26.80176	0,280
Threats with a weapon 03	5544	0.358947	2.259212	0,75
Threats without a weapon 03	5544	11.96429	49.833	0,2011
Thefts 03	5544	5.486652	11.15063	0,210
Gun Possessions 03	5544	0.185426	0.7764092	0,20
Knife Possessions 03	5544	0.752525	2.127136	0,30
Drug Distributions 03	5544	1.113636	3.441488	0,59
Alcohol Possessions 03	5544	4.362193	8.367233	0,100
Vandalisms 03	5544	3.867244	8.386934	0,123
% of students in the bottom 15% of Standardized Tests 03	5544	15.0202	14.81062	0,99

-Summary is for the SSOCS 2003-2004 data set for several variables. Dependent variable is the percentage of students in the bottom 15% of standardized tests. Independent variable is number of crimes.

Figure 1: Table of Summary Statistics for the 2003-2004 Data Set

We will control for this problem by focusing our analysis on the purely quantitative responses, and while some qualitative responses will be used (i.e. crime levels in districts), these will only be used when controlling for observable characteristics and will not be used directly in the analysis. Figure 1 (above) and Figure 2 (below) help to display the statistics that we preferred to work with, namely those consisting purely of records that can be checked against police reports.

The most concerning data trend lies in the small number of reported rapes across schools, an average of 0.024892 and 0.010646 for the 2003 and 2005 surveys, respectively. We feel that this might invalidate some of the causal inferences that could be drawn from the regressions involving the variable, which we will address later on in the data analysis section. The other oddity lies in the variable threats with a weapon as the maximum value is a statistical outlier for one school in each time period.

	Observations	Mean	Standard Deviation	Min, Max
Incidents 05	5548	44.05947	54.20575	0,617
Violent Incidents 05	5548	27.39574	40.58377	0,588
Rapes 05	5548	0.010646	0.1222326	0,3
Sexual Batteries 05	5548	0.108664	0.5849328	0,10
Robberies with a Weapon 05	5548	0.015419	0.2608768	0,10
Robberies without a Weapon 05	5548	0.509178	2.67695	0,57
Attacks with a weapon 05	5548	0.16116	1.980653	0,70
Attacks without a weapon 05	5548	15.99339	24.39549	0,387
Threats with a weapon 05	5548	0.389868	2.532256	0,75
Threats without a weapon 05	5548	10.20742	21.5624	0,348
Thefts 05	5548	6.041483	10.2188	0,80
Gun Possessions 05	5548	0.207783	0.9805142	0,22
Knife Possessions 05	5548	1.825991	2.826708	0,27
Drug Distributions 05	5548	3.520925	7.035325	0,80
Alcohol Possessions 05	5'548	1.311674	3.162707	0,31
Vandalisms 05	5548	3.755874	6.653662	0,60
% of students in the bottom 15% of Standardized Tests 05	5548	13.62151	13.71172	0,100

-Summary is for the SSOCS 2005-2006 data set for several variables. Dependent variable is the percentage of students in the bottom 15% of standardized tests. Independent variable is number of crimes.

Figure 2: Table of Summary Statistics for the 2005-2006 Data Set

In addition, an examination of these school districts suggests that double-counting of crimes, between threats and possession of weapons, may have occurred. Lacking the ability to identify which schools may have contributed to this counting issue, however, we let the data remain and included it in our regressions.

IV. Modeling

To demonstrate the difference between various types of crime, we present a regression model with gradually increasing controls across various observable characteristics in the hope of creating an accurate portrayal of the effect of crime on achievement of underperforming

students nationwide. We will begin with a simple regression that looks only at the effect of violent and nonviolent crime on achievement.

To proceed, we define A as the percent of students in the school who scored in the bottom 15% of standardized tests, for any given school district i and any given year m. We then define V, N as the number of violent and nonviolent incidents occurring at school i respectively. This yields the following model:

$$A_{i,m} = \alpha_0 + \beta_1 V_{i,m} + \beta_2 N_{i,m} + u_{i,m} \tag{1}$$

where the coefficient β_1 represents the effect of violent crimes on the percent of students in the bottom 15% of testing. Similarly the coefficient β_2 summarizes the effect of non-violent crimes on the same metric of achievement. By looking at these scores, as shown in Figure 3, we see that both coefficients are positive; crime has a negative effect on student achievement as there are more students scoring into the bottom 15% of test scores.

By looking at a different year as shown in Figure 4, however, the effect of non-violent crimes becomes statistically insignificant while the coefficient for violent crimes remains strongly significant, possibly indicating the existence of some form of bias within the regression as we would expect the numbers to be similar when using data sets from adjacent periods. Note that these regressions lack controls intentionally because they represent a "first-look" at the statistics on crime, a place that we believe most policy-makers and/or school administrators would stop.

In order to determine possible reasoning behind this strange change between the time periods, we will unpack the coefficients β_1 and β_2 into their respective crimes utilizing the empirical data provided in the survey. We hope that this will allow us to examine where the potential bias appears, so that we can specifically address it. We take β_1 and estimate the separate effects of (Rapes, Sexual battery, Robberies with a weapon, Robberies without a weapon, Attacks with a weapon, Attacks without a weapon, Threats with a weapon, Threats without a weapon, Gun possession, Knife possession). Similarly, β_2 separates into (Theft, Drug possession and distribution, Alcohol possession, Vandalism). This yields a new equation:

$$A_{i,m} = \alpha_0 + \mu_1 \delta_{1,i,m} + \mu_2 \delta_{2,i,m} + ... + u_{i,m} \tag{2}$$

where $\delta_{q,i,m}$ is the specific crime q, for each school i and year m.

Likewise μ_q represents the coefficient for each respective crime, displaying its effect on achievement.

In a further attempt to maximize the validity of our data by removing omitted variable bias, we then add in a control group $\vec{c}$ representing a control on community observables such as racial composition and crime levels. This yields a very similar equation:

$$A_{i,m} = \alpha_0 + \mu_1\delta_{1,i,m} + \mu_2\delta_{2,i,m} + ... + \vec{\sigma}\vec{c}_{i,m} + u_{i,m} \tag{3}$$

where $\vec{\sigma}$ is the coefficient on each respective characteristic. Controlling even further, we add in the vector $\vec{s}$ controlling for school observable characteristics ranging from teacher training, community partnerships, anti-crime policies, and established plans in case of various emergencies. This also yields a very similar equation:

$$A_{i,m} = \alpha_0 + \mu_1\delta_{1,i,m} + \mu_2\delta_{2,i,m} + ... + \vec{\sigma}\vec{c}_{i,m} + \vec{\rho}\vec{s}_{i,m} + u_{i,m} \tag{4}$$

where $\vec{\rho}$ is the coefficient on each respective school characteristic.

This we feel creates the most accurate model possible to determine the effect of crimes on the lowest achieving students. By controlling for as many observable characteristics as possible, we remove the maximal amount of bias possible from our model. By unpacking the categories of violent and non-violent crimes, we can distinguish ourselves from the majority of the current literature by directly examining the effect of specific crimes with achievement.

Our major concerns with omitted variable bias lie with our inability to include data on SES; the question was included in the actual survey, but results published did not include SES statistics in the data set. We feel like this would have a strong effect on raising the R-squared value, and its inclusion would reduce the effect of crime. In addition we feel that the inclusion of free and reduced lunch statistics would allow us to instrument for allocation of Title I funds, but unfortunately this was not included in the data sets.

V. OLS Regression Analysis

We will leave a portion of the data analysis to the reader, but would like to highlight a few basic points: The effect of nested violent and non-violent crimes, the effect of separating apart said variables and seeing the distinction within individual distinct crimes, the effect of

controlling for community observables, and the effect of controlling for school characteristics.

A basic regression on achievement from violent and non-violent crimes is displayed in (1)-figures 1,2 for 2003, 2005 respectively. The data from 2003 shows a distinct negative effect of both kinds of crimes, while 2005 only displays a significant effect from violent crimes, albeit a very significant effect. This shows the intuitive effect of crime on achievement, a step that many previous researchers, both academic and policy, have stopped at. We found that though the results from 2005 supported our argument that violent crimes were "worse" for achievement, we were left unsatisfied and wondering if specific crimes had different effects. Additionally, with an R-squared value of 0.01, it may be questionable to rely on this model as a basis for policy making.

Column (2) provides the effect of each individual crime, but some values seem to deviate from what is expected, specifically: rapes, threats with a weapon, theft, and alcohol possession. The data from 2003 show an insignificant effect of rape, robbery, all threats, drugs, alcohol and vandalism. Of these, the significance of rape and theft stand out as being unexpected. We felt that this may be due to individual characteristics of schools, and fully expected these to change once controls were put in place.

With the variable of rape, we specifically noticed that the average for each school was 0.0106, and the maximal value for any school was 3. This low number, along with the nature of the crime and possibility of it going unreported by victims, might have lead to this interesting pattern in both years. Further confusing us was the positive effect of theft; we postulate that theft may be a "basic" level of crime, as the survey defined an occurrence as any time when property over $10 was taken, and that vigorous punishment may deter peers from dabbling in related crimes, improving their academic achievement.

The data from 2005 show a generally more significant coefficients, but some values still seem curious. The t-value for rape still remains insignificant, and we postulated that the same effects from 2003 may still occur. Even more puzzling, however, is the fact that though theft becomes insignificant, the beneficial effect of alcohol possession becomes significant. Again, no clear explanation can be provided for this effect being positive, but we again postulate that it may be due to the same reasons as theft in 2003.

	(1)	(2)	(3)	(4)
Total Violent Incidents	0.023 (0.003)**			
Total Non-Violent Incidents	0.021 (0.009)*			
Rapes		-0.813 (0.963)	-1.004 (0.951)	0.298 (0.954)
Sexual Battery		0.416 (0.140)**	-0.067 (0.178)	-0.046 (0.178)
Robbery with a Weapon		-0.126 (0.246)	-0.335 (0.227)	-0.320 (0.226)
Robbery without a Weapon		0.553 (0.111)**	0.468 (0.117)**	0.466 (0.117)**
Attacks with a Weapon		-0.050 (0.079)	-0.215 (0.078)**	-0.242 (0.079)**
Attacks without a Weapon		0.082 (0.008)**	0.038 (0.009)**	0.039 (0.009)**
Threats with a Weapon		-0.052 (0.092)	-0.039 (0.087)	-0.051 (0.087)
Threats without a Weapon		-0.002 (0.004)	-0.003 (0.004)	-0.005 (0.004)
Theft		-0.112 (0.020)**	-0.094 (0.023)**	-0.094 (0.023)**
Gun Possession		1.399 (0.266)**	0.951 (0.277)**	0.944 (0.278)**
Knife Possession		0.411 (0.105)**	0.063 (0.107)	0.055 (0.108)
Drug Distribution		-0.008 (0.067)	0.076 (0.075)	0.048 (0.076)
Alcohol Possession		-0.011 (0.028)	-0.003 (0.029)	-0.001 (0.029)
Vandalism		0.037 (0.029)	-0.025 (0.029)	-0.011 (0.029)
Observations R-squared	5544 0.01	5544 0.05	4708 0.23	4708 0.24

- OLS regression models with 2003-2004 data set
- (3) controls for crime in school district, (4) controls for security measures, school plans, teacher training, community involvement
- Standard errors in parentheses
- * denotes significance at the $p < 0.05$ level; ** denotes significance at the $p < 0.01$ level

Figure 3: Regression Table for 2003-2004 Data

	(1)	(2)	(3)	(4)
Total Violent Incidents	0.080 (0.005)**			
Total Non-Violent Incidents	-0.002 (0.010)			
Rapes		0.061 (1.473)	-0.531 (1.441)	-0.515 (1.446)
Sexual Battery		0.676 (0.315)*	0.321 (0.309)	0.337 (0.307)
Robbery with a Weapon		3.111 (0.688)**	2.235 (0.954)*	2.218 (0.956)*
Robbery without a Weapon		0.295 (0.069)**	0.195 (0.072)**	0.196 (0.072)**
Attacks with a Weapon		0.815 (0.092)**	0.611 (0.109)**	0.610 (0.108)**
Attacks without a Weapon		0.059 (0.009)**	0.025 (0.009)**	0.022 (0.009)*
Threats with a Weapon		0.156 (0.073)*	0.075 (0.071)	0.081 (0.071)
Threats without a Weapon		0.043 (0.010)**	0.028 (0.010)**	0.025 (0.010)*
Theft		-0.065 (0.020)**	-0.044 (0.021)*	-0.042 (0.021)
Gun Possession		0.785 (0.186)**	0.574 (0.194)**	0.545 (0.193)**
Knife Possession		0.575 (0.077)**	0.329 (0.077)**	0.314 (0.077)**
Drug Distribution		-0.015 (0.032)	-0.027 (0.033)	-0.051 (0.033)
Alcohol Possession		-0.302 (0.067)**	-0.050 (0.072)	-0.046 (0.072)
Vandalism		0.045 (0.030)	0.013 (0.031)	0.009 (0.031)
Observations R-squared	5448 0.06	5448 0.10	4632 0.21	4632 0.23

- OLS regression models with 2003-2004 data set
- (3) controls for crime in school district, (4) controls for security measures, school plans, teacher training, community involvement
- Standard errors in parentheses
- * denotes significance at the $p < 0.05$ level; ** denotes significance at the $p < 0.01$ level

Figure 4: Regression Table for 2005-2006 Data

Controlling for the community effects of crime in the school area, crime in students neighborhoods, and racial demographics yields column (3), a more "accurate" display of the externalities of crime. In both the data sets for 2003 and 2005, this does not yield dramatic changes in the model results, despite increasing the t-values for some of the insignificant results.

Further controlling for the plethora of school characteristics, including teacher education with respect to crime and community partnerships, column (4) displays what we deem the most accurate representation of the effects of crime on education in current literature due to its effective use of controlling for observable characteristics and division into specific crimes. The supplementation of these controls most dramatically displays itself in the huge additions in statistical significance to knife possession and theft in both years, but somewhat curiously, it results in opposite changes in significance for threats with a weapon between the two years. This may possibly be due to the somewhat ambiguous nature of the question and possible cross-correlation with knife possession, as it is up to the principal if brandishing a knife would be classified as a threat or a possession crime.

With the full set of controls included (4), we were willing to begin addressing the importance of magnitudes for each individual crime, as well as several control variables. Among the statistically significant variables, the majority have a coefficient $-0.25 < \mu_q < 0.25$ (which represents a change in the percentage of low achieving students of less than 0.25%), which while significant from a statistical application, has what we would consider an insignificant impact when viewed through the lens of "real-world" changes. After these "insignificant" variables are removed, a strong change can only be seen in the categories of: Robbery without a Weapon, Gun Possession, Attacks with a Weapon, and Knife Possession. Of these, there are several inconsistencies between the two data sets, but the 0.466 coefficient on Robbery without a Weapon (2003) and 2.218 coefficient on Robbery with a Weapon (2005) represent significant detrimental correlations on the low achieving population. Additionally Gun Possession in both years, 0.944 and 0.545 coefficients respectively, also has a significant correlation with low achievement. Among the control variables used, the presence of crime within the region near the school had a very strong correlation with low achievement, which is to be intuitively expected. Other control variables fell within accepted and expected ranges.

The key findings of this analysis lie in the fact that even though

the vast majority of crimes deemed "violent" in the 2005 data set are strongly significant, none of the "non-violent" crimes are statistically detrimental to achievement; in fact the 2003 theft is beneficial possibly due to the peer effects from punishment discussed above. This shows a dramatic difference in the effects of specific crimes within each category, and shows that only by looking deeper within the variables can we show that contrary to popular belief and papers (Wei and Williams 2004), non-violent crimes are not detrimental towards achievement in struggling students.

VI. Error and Causality

Even though the data analysis supports the intuitive effects, it is important to examine any sources of possible error in our study. Due to our cross-section method of analyzing the data, we are unconcerned about the presence of serial correlation, though if our sets were to be combined it would need to be addressed. More concerning, however, is the probable presence of heteroscedasticity within our analysis, likely among associated variables (i.e. Attacks with a Weapon and Possession of a Knife). While it would be difficult to control for this error within the limits of our data set, based on the nature of the error, coefficients would remain unchanged if controlled and we would infer a slight drop in standard deviation. While this may make some variables statistically significant, their low coefficients would still render them "insignificant" from a policy perspective.

Additionally, there is a significant chance of some omitted variable bias in our study. As discussed earlier, the SSOCS does not include published information of SES through school lunches, which we believe would have a large impact on our R-squared value. We also wish that several variables included in later versions of the SSOCS (including the presence of metal detectors and security personnel) were available in early versions so that further study could be performed on cost-effectiveness of prevention measures.

It is also extremely important to highlight that while many of the correlations here may intuitively seem causal, our analysis is unable to effectively prove said claims. Instead we are only able to show a strong correlative effect which lends some weight towards a policy argument for causality. As discussed earlier, if the data set allowed for a longitudinal study (or a more effective quasi-experimental study) a much stronger argument towards causality could be evaluated.

VII. Conclusion

Our primary goals for this study were to analyze the untold effects of specific crimes in an attempt to create a greater body of knowledge in the field, and help to explain certain unexplained externalities within current data fields. Through our use of a regression model, we have successfully demonstrated this, and in fact have established an important differentiation between specific violent and non-violent crimes and their respective correlation on the achievement of underperforming students.

This could have dramatic policy implications within the modern school system as current funding through programs such as social norms highlight drug and alcohol usage while using significant sums of money. In a world described by Gary Becker that runs by the "Allocation of scarce resources to satisfy unlimited competing wants," educational policy makers must make the most efficient choices possible with their scant funding in the hope of creating a better tomorrow for their students. As our data analysis lends evidence that violent crimes have a strong negative effect on achievement while non-violent crimes do not, current policy makers should consider a change in funding allocation from non-violent crime prevention towards violent crime prevention in order to maximize efficiency.

References

[1] Barton, Paul, Coley, Richard J., and Wenglinsky, Harold. "Order in the Classroom: Violence, Discipline and Student Achievement." *Educational Testing Service*, Princeton, NJ, 1998.

[2] Henry, S. (2000). "What is School Violence? An Integrated Definition." *Annals of the American Academy of Political and Social Science,* 567:16-29.

[3] Lee, M. and Madyun, N. (2009). "The Impact of Neighborhood Disadvantage on the Black–White Achievement Gap." *Journal of Education for Students Placed at Risk*, 14: 148–169.

[4] MacMillan, R. and Hagan, J. (2004). "Violence in the Transition to Adulthood: Adolescent Victimization, Education, and Socioeconomic Attainment in Later Life." *Journal of Research on Adolescence*, 1(2):127-158.

[5] Hull, J. (2000). "Making a Safe Haven: A Review of School Safety Status, Perceptions and Practices in the South. Southern Legislative Conference." Retrieved from the website: www.csg.org/knowledgecenter/docs/slc-0004-SafeHaven.pdf

[6] Kramer, R. (2000). "Poverty, Inequality, and Youth Violence." *Annals of the American Academy of Political and Social Science*, 567:123-139

[7] Ringwalt, C. L., Ennett, S., and Johnson, R. (2003). "Factors Associated with Fidelity to Substance Use Prevention Curriculum Guides in the Nation's Middle Schools." *Health Education Behavior*, 30: 374-391.

[8] New York City Department of Education. (2007). "School Based Expenditure Reports." Retrieved from the NYCDoE website.

[9] U.S. Department of Education. (2010). Indicators of School Crime and Saftey:2010. (NCES Publication No.2011-002). Retrieved from the National Center for Education Statistics website.

[10] U.S. Department of Justice. (2009). "National Crime Victimization Survey: School Crime Supplement," 2007. (ICPR 2009-03-26). Retrieved from Inter-university Consortium for Political and Social Research website.

[11] Wei, H. and Williams, J.H. (2004). "Relationship Between Peer Victimization and School Adjustment in Sixth-Grade Students: Investigating Mediation Effects." *Violence and Victims.* 19:557-571.

[12] Welsh, W. (2000). "The Effect of School Climate on School Disorder." *Annals of the American Academy of Political and Social Science*, 567:88-107.

Don't Fear the Reaper: Analyzing the Effect of Health on Microfinance Participation

Sam Thompson

Abstract

The randomized introduction of microfinance to neighborhoods surrounding Hyderabad, India provides an opportunity to analyze the relationship between health and an individual's decision to borrow. Employing the Abdul Latif Jameel Poverty Action Lab's data from the aforementioned randomized controlled trial (RCT), I find that healthy individuals (those who lose fewer than 15 working days a year to illness) are significantly more likely to participate in microfinance. Accounting for intra-neighborhood correlation, however, the inclusion of clustered standard errors reduces the significance of said findings. This result suggests the importance of local networks in influencing investment and has broader policy implications in the need to construct a more localized, holistic model for developmental aid.

I. Introduction

The first of the United Nations' Millennium Development Goals sets the ambitious target of eradicating extreme poverty and hunger. Established at the General Assembly's Millennium Summit in 2000, the first of eight goals specifically calls for halving the proportion of people living on less than 1.25 dollars a day, achieving full and productive employment for all, and halving the proportion of people who suffer from hunger, all by 2015 [1]. Rising alongside this global target are a myriad of developmental solutions seeking, with the best of intentions, to mitigate the world's socioeconomic disparities. Proliferating from 7.6 million to 137.5 million participant families between 1997 and 2010,[2] microfinance (an initiative characterized by small loans given to the impoverished) is perhaps the most prominent of the proposed panacea for the United Nations' social and economic development tar-

[1] United Nations Development Programme, United Nations Millennium Development Goals (2000).

[2] 137 Million of World's Poorest Received a Microloan in 2010." Microcredit Summit Campaign (2010). *http://www.microcreditsummit.org/news/29/137-million-of-world-s.html* (accessed November 10, 2013).

gets. That being said, are such microloans, in fact, a cure-all?

Seeking to answer this question, the Massachusetts Institute of Technology's Abdul Latif Jameel Poverty Action Lab (JPAL) conducted a randomized controlled trial with Spandana, a microfinance institution hoping to establish itself in Hyderabad, India. Ensuring a gradual introduction of Spandana into the region, JPAL isolated the "treatment" of microcredit availability and thereby quantified its effect on the rural communities to which it was offered. While ultimately uncovering microfinance's limited role as a developmental panacea (there was no significant effect on either the expected social outcomes or on the likelihood of starting a business), JPAL's study was plagued by a conspicuous weakness: microfinance participation among eligible borrowers was only 27 percent.[3] Surprised by such low participation for a program that, in its onset, was so hailed that its founder won the Nobel Peace Prize, I raise the question as to what impedes an individual's participation in such aid initiatives as microfinance.

Establishing a behavioral foundation, I maintain that even the most impoverished function as rational economic actors in the pursuit of happiness and the avoidance of suffering. As such, their decisions are made on the margin. Because the impoverished frequently live in environments beset by complex vulnerability, they may lack faith in their ability to reap long run marginal benefit. In this way, cumulative risk skews the poor's decision making process towards immediate gratification and away from longer term aid initiatives. Specifically, my study analyzes the relationship between health (the lack thereof posing a significant risk factor) and microfinance participation with the hypothesis that healthy individuals will be more likely to take microloans.

Because this study is largely an addendum to JPAL's analysis of microfinance efficacy in Hyderabad, India, I employ the same data set but instead seek to isolate health as a factor in their relatively low program participation. Manipulating existing statistics to serve this purpose, I created a dummy variable ("healthy") that tested positive if an individual had lost fewer than fifteen working days to illness in the previous year. The number fifteen was selected because it is the median value above which the number of days ill increases dramatically. This metric for health functioning as the model's key explanatory variable, the threat of endogeneity is mitigated by both the nature of the

[3] Abhijit Banerjee and others, "The Miracle of Microfinance? Evidence from a Randomized Evaluation," Abdul Latif Jameel Poverty Action Lab (2013).

source experiment and the inclusion of various controls in the model. To preserve exogeneity in the initial study, JPAL randomly selected 104 participant neighborhoods, 52 of which were again randomly selected to receive the treatment: the introduction of Spandana. Such random assignment of the treatment and control groups ensures variation in the variables of interest. Additionally, the inclusion of wealth, age, education, marital status, and the presence of children under the age of two as controlling factors helps quantify otherwise unobservable variation in the model. This, coupled with the admission of insurance, titled home ownership, and government and family assistance as additional covariates, works to prevent correlation between the model's error term and its variables, thereby ensuring exogenous variation.

First assuming the independence of individual characteristics, my parameter estimates suggest a 2.9 percent increase in the likelihood of microfinance participation for a "healthy" individual. This finding is both statistically (at the 1 percent significance level) and economically significant as one of many risk factors impeding investment. Similarly significant factors indicated in this study are insurance ownership as well as the receipt of government assistance. This result is logical considering that both insurance and welfare programs seek to mitigate risk. A healthy individual with both insurance and government welfare functioning as safety nets may be even more confident in his or her ability to realize a long run return on investment and thereby more willing to take a microloan.

Addressing the potential for peer-group effects, I incorporate clustered standard errors into this study's final model. While "healthy" individuals remain 2.9 percent more likely to participate in microfinance, this result is statistically significant at only the 10 percent level. Similarly reducing the significance of both government assistance and insurance, these results suggest the influence of the local community on individual marginal analysis. When considering the channels of influence provided by a peer-group, this change is logical. For example, the presence of an informal insurance network or the "bandwagon effect" of neighbors participating in microfinance may partially account for variation in individual willingness to invest.

While the convoluted nature of both health and neighborhood effects impair my ability to assert complete causality, the policy implications regarding the restructuring of foreign aid remain profound. In whole, the increasing economic significance of layered risk mitigation

illustrates the importance of a more holistic aid program that may alleviate the complex vulnerabilities plaguing the impoverished and thus increase the efficacy of existing aid initiatives. Additionally, diminishing statistical significance upon the inclusion of clustered standard errors suggests the importance of aid initiatives tailored to local environments.

The remainder of this study is organized into the following sections: background, data, empirical model, results, and interpretation and conclusion. In discussing this study's background I will define the structure of traditional microfinance initiatives and explore existing literature concerning the market repercussions of risk. Next, the data section further elucidates the nature of the JPAL study to which this paper functions as an addendum and discusses potential measurement shortfalls. The empirical model section explicitly defines the econometric model and discusses how it conforms to the underlying economic theory while also addressing potential sources of bias. Following this, the results portion will include a preliminary interpretation of both the summary statistics and the regression analysis in order to establish a mathematical foundation for subsequent conclusions. Finally, the potential for causality and the broader policy implications of this study's findings will be discussed in the interpretation and conclusions portion.

II. Background

Built upon the perceived economic empowerment to be attained by universal access to credit, microfinance is fundamentally a program by which small loans are granted to poor individuals previously barred from formal banking services. Founded by Dr. Muhammad Yunus of Chittagong University in Bangladesh, Grameen Bank represents the traditional model for microfinance institutions. Specifically, Grameen loans to small groups of women who meet regularly and share liability for one another's debts. Loans are given solely to women based on the notion that they will be more likely than their male counterparts to invest in the family, thereby cultivating such social benefits as improved health and education in addition to more general financial growth. Collective responsibility and social pressure function to incentivize screening of potential group members (thus shifting the burden away from lenders) and ultimately cover the expenses if an individual borrower defaults. Consequently, Grameen is renowned

for extremely low default rates and is thereby able to charge similarly low interest rates. Spandana, the microfinance institution posing the subject of this particular study, follows the Grameen model in that it loans only to small groups of eight to ten women on the basis of shared liability.

The inherently small nature of microloans coupled with their gradual repayment rates make participation in microfinance institutions a decidedly long term investment. The social and economic costs associated with group lending make evident the marginal cost of borrowing; therefore, the key to augmenting microfinance participation is illustrating its long run marginal benefit. The importance of forward-thinking marginal analysis is made evident in the Hyderabad study through a disparity in results between the "business-minded" and not. Specifically, "fifteen to eighteen months after gaining access [to microfinance], households are no more likely to be entrepreneurs (that is, to have at least one business), but they are more likely to start more than one business, and they invest more in the businesses they do have."[4]

Recognizing this difference, the question then becomes how best to instill in an individual a mind for business, for this cadre of entrepreneurs has the most distinct marginal benefit and therefore the greatest participation incentive. The broader economic theory underlying this study is the notion that what distinguishes business and non-business minded individuals is the relative temporal depth of marginal analysis. In this way, holistic risk mitigation is essential as "a sense of stability may be necessary for people to be able to take the long view." [5]

Presently, there is a growing literature concerning the tendency of risk to skew an individual's cost-benefit analysis towards immediate gratification. Logically, if one lacks faith in the ability to realize investment returns, he or she may be unwilling to forego short term "happiness" (be it in the form of satellite television or tobacco) in pursuit of long term goals. Because farming constitutes the primary profession in much of the developing world, a few studies specifically address agricultural risk factors like fluctuations in crop price and rainfall. The Journal of Risk and Insurance published one such study addressing the effect of crop-price indemnified loans both on farmers' decision to

[4] Abhijit Banerjee and others, "The Miracle of Microfinance? Evidence from a Randomized Evaluation," Abdul Latif Jameel Poverty Action Lab (2013)

[5] Abhijit Banerjee and Esther Duflo, "Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty" (New York: Public Affairs, 2012), 215.

borrow and their subsequent production choices. Specifically, Karlan, Kutsoati, McMillan, and Udry randomly designate treatment groups to whom they offer loans under the provision of partial forgiveness should crop prices fall below a specified threshold. To establish a basis for comparison, they also offer a more traditional loan (lacking the forgiveness component) to randomly selected control groups. Unfortunately, while there was an economically significant increase of 23.1 percentage points in agricultural investment among the treatment group (although not statistically significant upon the inclusion of all control variables), take-up of both loan structures was so high that a lack of variability in the key explanatory variable introduced bias.

Moving beyond specifically agricultural risk factors, the broader cost of fear poses a similar impediment to investment. In "The Cost of Fear: The Welfare Effects of the Risk of Violence in Northern Uganda," Marc Rockmore emphasizes intangible risk factors, for "the near-exclusive focus of the literature on the experience of violence ignores their losses due to persistent insecurity and uncertainty."[6] First employing geo-spatial data on violent activity to construct a model of real (the probability of a community being attacked in 2004) and perceived (apparent insecurity within the area) risk, Rockmore proceeds to analyze the relationship between the aforementioned model's fitted values and geographic welfare effects. Proxying welfare in terms of per capita household expenditure, there is a statistically significant decrease in consumption of three and eight percent for households exposed to objective and subjective risk, respectively.[7]

In a similar study, Londona, Mora, and Verwimp postulate that "the threat of violence or the anticipation of violent shocks oblige rural households to revert to subsistence agriculture and shift portfolio to less risky, but also less profitable activities."[8] Empirically analyzing this notion, the authors employ municipal data regarding military action against the civilian populace averaged between 1998 and 2008, the percentage of municipal hectares devoted to coca cultivation, the percentage of land allocated to coffee, and a variety of other economic covariates to model the relationship between risk and coffee produc-

[6]Marc Rockmore, "The Cost of Fear: The Welfare Effects of the Risk of Violence in Northern Uganda," Households in Conflict Working Paper 109 (2011), 2.

[7]Ibid., 20.

[8]Ana Londono, Juan Mora, and Philip Verwimp, "Abandoning Coffee under the Threat of Violence and the Presence of Illicit Crops. Evidence from Colombia," Households in Conflict Working Paper 150 (2013), 2.

tion.

Recognizing that "abandoning coffee production is an extreme strategy households may adopt to mitigate the impact of shocks or to reap the short-term benefits of coca production,"[9] this relationship applies to my study as an example of the broader tendency of risk to skew marginal analysis towards short-run benefit. While the regression statistics suggest that an increase in one standard deviation of average military action coincides with a 0.02 standard deviation decrease in the percentage of land devoted to coffee production,[10] the inherent difficulty of quantifying the amount of illegal coca production impedes the authors' ability to move beyond conjecture in terms of the farmers' transition from long-run to short-run profitability as embodied in the shift from coffee to coca cultivation.

Slight biases notwithstanding, these studies are exceedingly relevant as the threat of violence poses a level of uncertainty comparable to poor health, and "the literature on choice under uncertainty provides a framework for understanding the role of risk in household decisions."[11] My paper improves upon the existing research, however, by employing a specific aspect of the larger, often intangible vulnerability networks to a partial explanation of Spandana's conspicuously low participation rates. From a policy perspective, my study further advocates "the importance of subjective risk [in] the provision [that] aid may need to be reconsidered."[12]

III. Data

As mentioned above, this study functions as an addendum seeking to partially explain low participation rates among eligible borrowers in JPAL's analysis of microcredit efficacy: "The Miracle of Microfinance? Evidence from a Randomized Evaluation." Consequently, I utilize JPAL's data set in analyzing health as an impediment to borrowing among their targeted sample population. More specifically, I derived both demographic statistics and loan information from a comprehensive endline survey conducted three years after the controlled

[9] Ana Londono, Juan Mora, and Philip Verwimp, "Abandoning Coffee under the Threat of Violence and the Presence of Illicit Crops. Evidence from Colombia," Households in Conflict Working Paper 150 (2013), 2.

[10] Ibid., 27.

[11] Marc Rockmore, "The Cost of Fear: The Welfare Effects of the Risk of Violence in Northern Uganda," Households in Conflict Working Paper 109 (2011), 3.

[12] Ibid., 26.

introduction of Spandana.

Considering the study's setting in rural communities surrounding Hyderabad, India, there was no accurate census data. As a result, JPAL commissioned a hasty baseline survey in order to attain basic information by which to determine eligible neighborhoods. With the intention of surveying 20 households per neighborhood, field officers mapped prospective communities and selected every nth house. Ultimately, 2,800 households were surveyed and 104 neighborhoods deemed eligible. Of these, communities were paired by common characteristics with one of each couple allocated to the treatment group to host a newly created Spandana branch. With the experimental groups thus created, field officers conducted two comprehensive household surveys (65 homes per neighborhood for a total of 6,850) spaced one and three years following the initial introduction of Spandana. The homes selected were those with the highest likelihood of having borrowed: residents of the area for a minimum of three years with at least one woman between the ages of 18 and 55. The latter of these two assessments constitutes the final endline survey from which I derived my cross-sectional data set.

While the comprehensive nature of the endline survey largely mitigates the threat of sampling error (nearly every household eligible to receive a microfinance loan was assessed), survey data is inherently flawed due to the prevalence of measurement error. Namely, while the dependent variable is a simple question of whether or not the individual has taken a microloan in the past three years, the key explanatory variable (the number of days lost to illness in a year) is more difficult to precisely recall. Because I opted to construct a binary variable deeming "healthy" those individuals with fewer than 15 working days lost to illness, such rounding error is significant on the margin of healthy and unhealthy. That being said, there should be an equal likelihood that surveyed individuals either under or overestimate the number of days ill, so the overarching effect should be minimal. Additionally, rounding error in the endline survey is prevalent in the valuation of one's household assets. Similar to the reported number of sick days, issues arise on the margin of low and medium wealth (1,700 rupees). As may be referenced in the attached summary statistics (Appendix A), the percentage of individuals deemed to be of medium wealth and the percent considered of low wealth are fairly equal. Considering the relative poverty that makes these neighborhoods desirable for microfinance involvement, these findings could potentially be skewed to-

wards higher wealth by social desirability bias. Furthermore, the percentage of households receiving family assistance (conspicuously low despite the historic prevalence of such informal insurance networks), may also suggest a slight social desirability bias towards perceived self reliance.

Ultimately, the meticulous construction of the randomized controlled trial from which my data is derived reaffirms its ability to produce useful results. While some measurement error may stem from the data being survey based, rounding error and social desirability bias should have minimal effects on the few explanatory variables that require more specific reflection. Namely, rounding may conceivably occur either above or below the true value, and the relatively uniform poverty of the area in question should minimize the desire to artificially inflate one's wealth. Otherwise, the comprehensive screening of randomly selected control and treatment groups should ensure a representative sample with sufficient variation in the explanatory variables to produce meaningful results.

IV. Empirical Model

Utilizing the econometric model depicted below, I empirically analyze the relationship between health and an individual's willingness to participate in microfinance. Accounting for both formal and informal risk mitigation tactics, I include ownership of an insurance policy (be it life, health, or property) and the receipt of government or family assistance as additional explanatory variables. Additionally, I incorporate a variety of controls into the model to minimize disparities in individual characteristics and economic circumstances thus isolating variation in the aforementioned explanatory variables.

$$Micro_i = \alpha + \delta_1 Health_i + \delta_2 Insure_i + \delta_3 Govassist_i + \delta_4 Famassist_i + \beta X_i + \epsilon_i \tag{5}$$

This being a linear probability model, the outcome of interest, *Micro*, is a binary variable indicating whether an individual has taken a microloan in the past three years. The primary explanatory variable, *Health*, is also a binary variable answering affirmative if an individual has lost fewer than 15 working days to illness in the past year. The three insurance network variables, *Insure*, *Govassist*, and *Famassist*, are again binary variables indicating whether an individual has any

insurance policy, receives any type of assistance from the government or from their family, respectively.

As discussed in the above literature review, both objective and subjective risk —such as crop price fluctuations or fear—influence household production decisions. Assuming rational economic actors, individual decisions are made on the margin. Therefore, such complex vulnerability affects choice by distorting perceived marginal cost and benefit. This model coincides with the overarching economic theory in that health is the culmination of a broad range of risk factors, the severity of which could shift marginal analysis away from long-run investment and towards more immediate gratification. The presence of both formal and informal insurance networks work to mitigate the risk of poor health and should therefore be included in the model as indicators of the long run decision to participate in microfinance.

To isolate variation in the key explanatory variable, this model includes controls for such factors as wealth, education, age, marital status, and the presence of children under age two. Given the intangible nature of perceived risk, it is important to consider these factors, as, for example, married individuals or those with children might be inherently risk averse. Also, the conspicuous absence of a gender variable is worth noting. Embracing a traditional microfinance model, Spandana solely issues loans to small groups of women. Despite this, the individuals compiling the data set collected a holistic census including both men and women. To better isolate the decision making process of the eligible females, I drop all male variables and solely analyze these factors among the female sample.

Potential shortfalls of this econometric model stem both from its being a linear probability model and from specification error in the form of omitted variable bias. While later testing of the parameter estimates addresses a common shortcoming of such models by verifying that no individuals have predicted probabilities of microfinance participation above one hundred or below zero percent, all linear probability models are inherently heteroskedastic. While this poses no threat of biased estimators, I am forced to include heteroskadisticity-robust standard errors in later regression analysis to preserve my ability to infer causality. Additionally, to better isolate the effect of microfinance introduction, JPAL formed treatment and control groups at the neighborhood level based on similarities in myriad controls. As such, Model 5 incorporates clustered standard errors in order to address the potential for intra-neighborhood correlation. The prominent

reduction in statistical significance suggests that the previous models wrongfully attribute willingness to invest entirely to personal characteristics while ignoring peer-group effects within one's village. Just as Moulton's Problem suggests that students' test scores are correlated with the composition of their classroom, [13]residents' propensities to invest are correlated with the composition of their community. In this way, an improved model for neighborhood characteristics is necessary to avoid under-specification.

Furthermore, while a randomized controlled trial would typically function to minimize disparities in individual characteristics (or at least ensure their random distribution), the original treatment and control groups were differentiated by the introduction of microfinance, not health characteristics. Consequently, despite my controlling for a variety of contributing factors, the convoluted nature of any health metric means that the model is likely underspecified. In this way, potential correlation between my unobserved error term and my key explanatory variable prompts omitted variable bias and threatens the assumption of exogenous variation. That being said, JPAL and Spandana's initial selection of neighborhoods was based on a common set of criteria defining ideal candidates for microfinance. In this way, while JPAL's experimental design of treatment and control groups is not directly beneficial to the question of health, the selection of neighborhoods based on similar criteria and the subsequent randomized introduction of Spandana within said sample help preserve the exogeneity of the health variable. Even still, health being an inherently convoluted notion, the selection of such a proxy variable as the number of days lost to illness poses an obstacle to causal inference. Coupling the endogeniety posed by this health metric with the under-specification of neighborhood composition, I am unable to establish direct causality between health and willingness to invest. Despite this, a comparison between Models 4 and 5 provides insight as to the influence of peer-group effects on microfinance participation.

V. Results

Overall, both my summary statistics and early regression analysis allude to a significant relationship between health and an individual's willingness to borrow. As may be referenced in Appendix A, there is

[13]Brent Moulton, "Random Group Effects and the Precision of Regression Estimates." *Journal of Econometrics* 32 (1986): 387-97.

a three percentage point increase in microfinance participation among those individuals deemed healthy. Regression analysis, in turn, reaffirms the trend suggested in the summary statistics as healthy women are 2.9 percent more likely to take a microloan. That being said, the incorporation of clustered standard errors reduces the explanatory variables' statistical significance. In this way, correlation within neighborhoods accounts for some of the perceived variation between health and microfinance participation.

First analyzing the summary statistics to determine whether the key explanatory variable is sufficiently exogenous and that the data generally coincides with underlying theory, the basic study proves valid and worthy of further regression analysis. Health being the primary explanatory variable, the disparity in participation between healthy and unhealthy demographics coincides with the notion that risk impedes the pursuit of long term goals. Hoping to isolate health as a source of exogenous variation, other variables should ideally remain fairly constant across the healthy and unhealthy groups. While there is some variation in the risk mitigating variables, the other covariates remain largely consistent between said groups, thus reinforcing the validity of the experimental design.

A noticeable exception, however, is the prominent increase in the percentage owning insurance among healthier individuals. As with the outcome of interest, the increase in insurance among the healthy may be partially attributed to a longer term marginal analysis. If an individual is healthy, perhaps he or she is more likely to have hope for the future and therefore consider the long term benefits of an insurance policy. While such correlation between explanatory variables hinders my ability to fully establish exogenous variation, it is better to include insurance in the model so as to empirically account for such a significant factor and thereby avoid the more damning effect of correlation between the unobserved term and the independent variable. The remaining two factors in which there are slight disparities in healthy and unhealthy samples are low wealth and medium wealth. Determined by the value of household assets, the demarcation between low and medium was based on the percentiles within the larger sample. Specifically, those individuals with household assets below the 50^{th} percentile are deemed "low wealth," while those between the 90^{th} and 50^{th} percentile are "medium wealth." Despite the logical, positive effect of wealth on health, the disparity is relatively small and should not significantly skew the results. Beyond the factors

discussed above, the "constant" variables remain consistent between the healthy and unhealthy groups, thereby more effectively isolating health as an exogenous explanatory variable.

Thus able to largely isolate variation in health *ceteris paribus*, regression analysis poses the next step in quantifying the proposed relationship between this comprehensive risk factor and microfinance participation. As illustrated in Appendix B, the naïve regression (Model 1) of health on microcredit history yields a 3.1 percent increase in the likelihood of having paid off a microloan within the past three years for those individuals deemed "healthy." This parameter estimate is valid at the 1 percent significance level; therefore, we have significant evidence to reject the null hypothesis that there is no relationship between health and microfinance participation. Model 2 incorporates formal risk mitigating systems such as insurance and government assistance as additional explanatory variables. In this regression, the parameter estimate for health decreases only slightly to 3.0 percent while both government assistance and insurance pose similarly significant factors at the 1 percent significance level. Prompting a 2.0 and 2.2 percent increase in the likelihood of microfinance participation, the inclusion of an insurance policy or government welfare program (respectively) pose economically significant forms of formal risk mitigation.

I include more informal risk mitigation in Model 3 through binary variables indicating titled home ownership and the receipt of family assistance. While these may be underestimated due to social desirability bias in survey responses, neither of these variables bears statistical or economic significance. Despite including an additional two variables, health and the two formal risk mitigating factors remain extremely stable between Models 2 and 3. Model 4 incorporates all controlling factors (wealth measured in the value of household assets, marital status, children under age two, age, and education) and thereby constitutes my fully specified model. Both health and government assistance remain stable across the latter two regressions whereas the return to insurance increases slightly (2.0 to 2.2 percent) upon the inclusion of the controls. Finally, Model 5 mirrors the fully specified regression but includes clustered standard error as a means to account for intra-neighborhood correlation.

While the parameter estimates are the same as those in Model 4, an increase in standard error proves detrimental to the model's statistical significance. Despite the consequent inability to infer causality

between health and propensity to invest, the disparity between Models 4 and 5 remains telling in terms of the need to craft localized aid initiatives that consider neighborhood composition.

Fundamentally, my regression analysis suggests that being "healthy" is correlated with a 2.9 percent increase in willingness to participate in microfinance. This parameter estimate remains stable throughout all five models in economic significance. While an increase in participation probability of only 2.9 percent may appear inconsequential, the underlying economic theory suggests that health is but a singular aspect of a multi-faceted vulnerability network impeding long-term investment. All five models' remarkably low correlation coefficients reaffirm this notion. Even when including all controls, the model only explains 0.6 percent of the variation in microfinance participation. That being said, when aid initiatives bolster health in conjunction with insurance and more general government assistance, the effect compounds to a 6.5 percent increase in willingness to participate. In this way, more risk factors must be empirically identified in order to account for more variation in microfinance uptake.

VI. Interpretation and Conclusion

Pursuing a more holistic model for developmental aid, this study addresses the broader effect of risk mitigation on the willingness of an individual to forego short term "happiness" in pursuit of long term goals. As discussed above and illustrated in Appendix B, this model suggests a 2.9 percent increase in willingness to take a microloan among "healthy" individuals (valid initially at the 1 percent significance level and later at 10 percent). Despite the economic significance of this result, I hesitate to infer causality due to the threat of omitted variable bias inherent both in using the number of working days lost to illness as a singular proxy for the convoluted notion of health and in neglecting to model peer-group effects.

The reduction in statistical significance stemming from the incorporation of clustered standard error suggests the correlation between such peer-groups and propensity to invest. By failing to account for the Moulton Problem of intra-group correlation, I overestimate the reliability of group-level parameter estimates. Be it through informal insurance networks or a psychological "bandwagon effect," the intricacies inherent in quantifying individual motivation within a neighborhood hamper one's ability to isolate health as an exogenous, causal

factor.

Rather, while this study specifically analyzes the effect of health on microfinance participation, it constitutes a limited step in establishing a broader causal relationship between myriad risk factors and the exploitation of existing aid initiatives. In this way, while the complexity of one's willingness to participate relegates these findings to a state between correlation and causation, the policy implications remain profound. A positive relationship between health and willingness to participate should influence the structure of developmental programs by incorporating such risk mitigating components as insurance to supplement traditional capital inflows. Additionally, the prominence of intra-neighborhood correlation affirms the need for a nuanced understanding of village composition so as to increase aid efficacy through more localized programs.

This model's extremely low correlation coefficient elucidates the need for a multi-faceted approach to explaining variability in microfinance participation. Further research should be conducted to identify significant risk factors impeding long-run marginal analysis. Furthermore, the complex nature of local vulnerability networks asserts the need for replication within different communities, for geographic disparities may alter the relative importance of certain risk factors. With thus localized models of risk, the international aid community must develop a more holistic developmental package by which to mitigate community risk and thereby augment participation in (and the consequent efficacy of) conventional aid programs like microfinance. To foster grassroots economic development, companies like Spandana must move beyond a paltry 27 percent participation rate among eligible borrowers by alleviating risk that otherwise relegates the impoverished to short-run marginal analysis. First improving the health of rural residents in Hyderabad, India, Spandana and the Abdul Latif Jameel Poverty Action Lab must continue to develop a holistic model of risk so as to facilitate localized growth.

References

[1] "137 Million of World's Poorest Received a Microloan in 2010." *Microcredit Summit Campaign* (2010). http://www.microcreditsummit.org/news/29/137-million-of-world-s.html (accessed November 10, 2013).

[2] Banerjee, Abhijit and Esther Duflo, "Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty." New York: Public Affairs, 2012

[3] Banerjee, Abhijit, Esther Duflo, Rachel Glennerster, and Cynthia Kinnan. "The Miracle of Microfinance? Evidence from a Randomized Evaluation." Abdul Latif Jameel *Poverty Action Lab* (2013) http://www.povertyactionlab.org/evaluation/measuring-impact-microfinance-hyderabad-india (accessed October 15, 2013).

[4] Londono, Ana, Juan Mora, and Philip Verwimp. "Abandoning Coffee under the Threat of Violence and the Presence of Illicit Crops. Evidence from Colombia." *Households in Conflict Network.* 150 (2013).

[5] Moulton, Brent. "Random Group Effects and the Precision of Regression Estimates." *Journal of Econometrics* 32 (1986): 387-97.

[6] Rockmore, Mark. "The Cost of Fear: The Welfare Effects of the Risk of Violence in Northern Uganda." *Households in Conflict* Working Paper No. 109, 2011.

[7] United Nations Development Programme. *United Nations Millennium Development Goals* (2000) (accessed November 19, 2013).

Appendix A: Summary Statistics

TABLE 1 SUMMARY STATISTICS

:

Variable Description	Healthy (Less Than 15 Days of Work Lost to Illness)	Unhealthy (More Than 15 Days of Work Lost to Illness)
Participated in Microfinance in the Last Three Years	0.152 (0.359)	0.121 (0.326)
Insurance	0.566 (0.496)	0.507 (0.500)
Assistance From Government	0.616 (0.486)	0.609 (0.488)
Assistance From Family	0.108 (0.311)	0.110 (0.313)
Titled Homeowner	0.799 (0.401)	0.795 (0.403)
Low Wealth (Less Than 1700 Rupees)	0.435 (0.496)	0.464 (0.499)
Medium Wealth (Between 1700 and 19200 Rupees)	0.443 (0.497)	0.413 (0.492)
Married	0.607 (0.488)	0.635 (0.482)
Children Under the Age of Two	0.232 (0.422)	0.259 (0.438)
Highest Year of Education	9.674 (3.398)	9.585 (3.484)
Age	27.006 (9.775)	27.071 (10.198)
Number of Observations	2164	6869

Notes: Sample means are reported with the corresponding standard deviations listed below in parentheses. Data is from Bannerjee, A., Duflo, E., Glennerster, R., and Kinnan, C. "The Miracle of Microfinance? Evidence From a Randomized Evaluation." *Jameel Abdul Latif Poverty Action Lab,* (April 2013). Specifically, the data is derived from an endline survey conducted two years after the introduction of the microfinance institution, Spandana, into the sample area.

Figure 5: Table 1

Appendix B: Regression Results

TABLE 2: Regression Results
The Impact of Health On Microfinance Participation

Variable description	Model 1	Model 2	Model 3	Model 4	Model 5
Healthy (Less Than 15 Working Days Lost to Illness)	0.031*** (0.008)	0.030*** (0.008)	0.030*** (0.009)	0.029*** (0.009)	0.029* (0.016)
Insurance	---	0.020*** (0.007)	0.020*** (0.007)	0.022*** (0.007)	0.022 (0.014)
Receive Assistance from Government	---	0.022*** (0.007)	0.022*** (0.007)	0.021*** (0.007)	0.021* (0.011)
Receive Assistance from Family	---	---	0.006 (0.011)	0.007 (0.012)	0.007 (0.018)
Titled Homeowner	---	---	-0.003 (0.009)	0.000 (0.008)	0.000 (0.021)
Low Wealth (Less Than 1700 Rupees)	---	---	---	0.000 (0.012)	0.000 (0.019)
Medium Wealth (Between 1700 and 19200 Rupees)	---	---	---	0.002 (0.011)	0.003 (0.016)
Married	---	---	---	-0.005 (0.008)	-0.005 (0.012)
Children Under Age Two	---	---	---	-0.019** (0.008)	-0.019 (0.012)
Highest Year of Education	---	---	---	-0.006*** (0.001)	-0.006*** (0.002)
Age	---	---	---	-0.001*** (0.000)	-0.001*** (0.000)
Constant	0.117 (0.004)	0.105 (0.009)	0.099 (0.009)	0.190 (0.022)	0.190 (0.041)
Clustered Standard Error	NO	NO	NO	NO	YES
Regression R^2	0.001	0.004	0.004	0.008	0.008
Number of observations	7740	9033	9033	9027	9027

NOTES: Models 1-4 include coefficient estimates with heteroskedastic robust standard errors in parentheses. Model 5, however, includes clustered standard errors in parentheses. All regressions include a constant term.
*** Denotes Statistical Significance at the 1% Significance Level
** Denotes Statistical Significance at the 5% Significance Level
* Denotes Statistical Significance at the 10% Significance Level

Figure 6: Table 2

Notes

Notes

Acknowledgements

The staff of *The Developing Economist* would like to thank the Department of Economics, the College of Liberal Arts, and the Student Government at the University of Texas at Austin for their generous support and access to resources.

We would like to recognize esteemed alumni and *Developing Economist* founders Mr. Affonso Reis and Mr. Alan Lujan for their ongoing counsel and for laying a solid foundation for this project.

Additional thanks are extended to the Omicron Delta Epsilon Honor Society.

Printing: UT Copy Services

Contact: developingeconomist@gmail.com

Website: *www.developingeconomist.com*

Cover Information: *www.utexas.edu*