Inflation and Productive Capacity - An Empirical Risk Reduction Model

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August 23, 2021

Abstract

An economy's ability to provide food, energy, and manufactured goods for its population to consume reduces the chance that it experiences high consumer price inflation. However, no research has been done on exactly how much of these critical goods a country needs to be able to produce to keep inflation low and manageable. In this paper, I use an empirical risk reduction model to analyze over seven hundred and fifty data points from twenty-five countries over a thirty-eight-year period to show that a country can significantly reduce it chance of experiencing medium inflation and virtually eliminate the risk of hyperinflation by improving productive capacity such that its output of critical goods is approximately 174% of what the average person would consume in a country with a high standard of living.

Introduction

An economy's ability to provide food, energy, and manufactured goods for its population to consume reduces the chance that it experiences high consumer price inflation, even after adjusting for the growth in spending by its government. The precise nature of this relationship has never been empirically investigated. The existing literature surrounding the impact of productive capacity on inflation has argued that there is some minimum amount of goods and services that a nation must be able to create to avoid hyperinflation. However, to my knowledge, no research has studied a large sample of different countries over a period of several decades to determine the effect of different levels of production on inflation risk. This study fills this gap in the research by introducing a model that allows governments to create guidelines for exactly how much a country should produce to maximize its chances of keeping inflation low.

Literature Review

Two of the most prominent examples of hyperinflation in the last hundred years can be traced to severe reductions in productive capacity. Mosler and Armstrong (2020) note that following the destruction of productive capacity following World War I and the French invasion of the Ruhr, output in the Weimar Republic was limited, forcing the government to pay higher prices to compete for goods and services, leading to hyperinflation.[i] Madima (2020) similarly shows how hyperinflation in Zimbabwe came after land reform, price freezes, and other measures "destroyed the country's capacity to produce and manufacture food", forcing citizens to rely on imports.[ii]

Arestis and Sawyer (2005) used the empirical studies linking demand and capacity to create a formal model of the structuralist view of inflation; they concluded that productive capacity is a major determinant of the inflation barrier.[iii] They also argue that policies that stimulate demand and investment underpin full employment; in contrast, policies "which attempt to tame inflation through higher levels of unemployment can cause the inflation barrier to fall, thereby sustaining higher levels of unemployment."[iv]

The difference between the productive capacity of developed economies and the productive capacity of developing economies often shows up in pass-through inflation. The literature suggests the specific industries in which productive capacity are most important to preventing inflation and pass-through inflation are food, energy, and manufacturing. Kaboub et al. (2020) argue that the primary cause of imported inflation in African countries is a lack of investment in productive capacity for food, energy, and high value-added manufacturing.[v] Ridhwan (2016) found that differences in inflation rates between regions in Indonesia were "mainly due to differences in productive capacity (manufacturing and industry)" and "asymmetric shocks caused by sectoral specialization."[vi] Bose (2012) investigated the causes of inflation in India after a series of rate hike by the Reserve Bank of India from 4.75% to 8.75% from December 2009 to January 2012 failed to reduce inflation.[vii] Bose instead found that food consumption grew at a faster rate in India in the 2000s than food production, leading to a rise in food prices that carried over into the rest of the economy.[viii] Bose argued that because food is a necessity, monetary policy was unable to reduce food consumption and that therefore public policy should focus on investing in food production and solving issues in the distribution and pricing of strategic commodities to moderate inflation while reducing adverse impacts to low-income households.[ix]

In contrast, Hafer (1989) found in his review of the literature on exchange rate pass-through inflation that changes in the exchange rate for the US Dollar had weak impacts on overall inflation – a 10% change in the exchange rate might only increase inflation by 1-2% and near zero when controlling for oil price shocks.[x] He argued that when a domestic economy produces items, not only will importers hesitate to raise prices to compete with domestic goods and capture market share, but consumers will also shift consumption away from expensive imported goods and towards less expensive domestic goods.[xi]

Garner (1994) looked specifically at the empirical link between inflation and domestic capacity utilization of the manufacturing sector in the United States from 1964-1993.[xii] In contrast to claims that changes in productivity, technological prowess and trade openness would reduce the impact of domestic manufacturing capacity utilization, Garner found that manufacturing capacity utilization remained a reliable indicator of inflationary pressures – even after adjusting for the capacity utilization of the United States' largest trading partner.[xiii]

Finally, de Carvalho, Ribeiro & Marqes (2008) examined how the stage of economic development of a country affected inflation.[xiv] They found that heightened levels of economic prosperity (per capita income), of the share of high-tech exports and of unemployment growth corresponded to lower inflation rates.[xv]

Model

The model assumes that the probability of inflation occurring above a given threshold is affected by both the actual production of vital goods and services and government expenditures. The hypothesis, derived from the findings of Mosler and Armstrong (2020) is that if actual production falls, the government must choose between allowing its population to endure poverty and attempting to claim the same amount of vital goods and services for use in the public sector. If production is down, the government must compete with private sector buyers by paying higher prices, leading to inflation. P(I) is the probability of the selected country or group of countries experiencing inflation in a given range I. The actual level of vital goods and services produced is expressed as R, also referred to in this model as the Resource Score. The growth in the level of government expenditures from the previous period is expressed as G Finally, α and β are the regression coefficients affecting R and G, respectively, and Δ is the y-intercept of the equation. Equation 1 in the model can be expressed as follows.

Equation 1 $$P(I) = \alpha R + \beta G + \Delta$$

The Resource Score R is determined by adding the selected country's Food Resource Score R_F, its Energy Resource Score R_E, and its Manufacturing Resource Score R_M. Equation 2 can be expressed as follows.

Equation 2 $$R = R_F + R_E + R_M$$

To calculate the scores for the three resources, I took the country's annual value of agricultural production for food, F, its annual total primary energy production in Btu, E, and its annual value added from manufacturing, M. Each of F, E, and M are divided by an expression consisting of the product of the country's population, P, multiplied by 365 (representing the number of days in a year), and a standard consumption coefficient, C_F, C_E, or C_M. Each of the consumption coefficients approximate the annual consumption of an individual with a high standard of living for the given variable. Therefore, for each production variable, a score of 1 indicates that the country produces exactly as much of the production variable for its entire population to consume while maintaining a high standard of living, assuming perfectly equal distribution. Equations 3, 4, and 5 can be expressed as follows.

Equation 3 $$R_F = F \div (C_F * P * 365)$$
Equation 4 $$R_E = E \div (C_E * P * 365)$$
Equation 5 $$R_E = M \div (C_M * P * 365)$$

Equation 6, consisting of the entire model, can be expressed as follows.

$$P(I) = \alpha[F \div (C_F * P * 365) + E \div (C_E * P * 365) + M \div (C_M * P * 365)] + \beta G + \Delta$$

Methodology

To test whether the model accurately predicted a reduction in inflation probability, I looked at data from 35 countries spanning a period from 1981 to 2018. Data for each of the resource scores were taken from the Food and Agriculture Organization of the United Nations; the U.S. Energy Information Administration; and the United Nations Statistics Division, National Accounts Main Aggregates Database. The values for food and manufacturing value added used constant 2014-2016 USD and 2015 USD, respectively. The following countries were in the sample:

Argentina	Australia	Bangladesh	Brazil
China	Colombia	Egypt, Arab Republic	Ethiopia
France	Germany	Greece	Iceland
India	Indonesia	Iran, Islamic Republic	Italy
Japan	Kenya	Korea, Republic	Mexico
Nigeria	Pakistan	Philippines	Russian Federation
South Africa	Spain	Sweden	Thailand
Turkey	United Kingdom of Great Britain and Northern Ireland	United Republic of Tanzania	United States of America
Venezuela, Bolivarian Republic	Vietnam	Zimbabwe	

For the standard consumption coefficient for energy, I used 457,671 Btu, which is the average Btu per person consumed in Germany.[xvi] For the standard consumption coefficient for food, I used $3.58, which is the average food expenditures for consumers in the US in 2019 multiplied by 16%, which represents the amount of the purchase price that represents the raw ingredients purchased from the farmer.[xvii] [xviii] For the standard consumption coefficient for manufactured goods, I used $2.46, which is the consumption of durable goods in the US in 2015, per person, per day, multiplied by 22%, which is the percentage of demand for manufactured goods which comes from manufacturing value added.[xix] [xx] The year 2015 was used because it was the year for which manufacturing value added is adjusted for inflation in the national accounts database from the United Nations. Data points were only included in the sample if there are information is available for each category: food production, energy production, manufactured goods production, population, government expenditure growth, and inflation for the five years following the given year.

To control for the possibility that causality might exist in reverse, I compared the Resource Score of each country to the average inflation it experienced that year and over the next five years. Each data point in the set represents a one country at one year with one Resource Score and one inflation value or adjusted inflation value that represents the average inflation over the five years following the year the Resource Score was measured. To determine the probability of inflation occurring at a given level of Resource Score or government expenditures, I grouped every data point with a Resource Score between a given ten percentile range, excluding Resource Scores below the tenth percentiles and Resource Scores above the 90^{th} percentile. I did the same with the percentage changes in government expenditures to create the following categorizations. There were approximately 77 data points in each Resource Score band and approximately 77 data points in each government expenditure band. The average values in each band were treated as the independent variables in each set of data points.

Percentile Band	Resource Score Band	Resource Score Average Value	Change in Government Expenditure Band	Change in Government Expenditure Average Value
10^{th} to 20^{th}	0.31 to 0.61	0.40	0.19% to 2.66%	1.16%
20^{th} to 30^{th}	6.1 to 1.00	0.73	2.66% to 5.22%	3.98%
30^{th} to 40^{th}	1.00 to 1.68	1.40	5.22% to 7.25%	6.16%
40^{th} to 50^{th}	1.68 to 2.66	2.07	7.25% to 9.98%	8.58%
50^{th} to 60^{th}	2.66 to 4.14	3.46	9.98% to 13.01%	11.40%
60^{th} to 70^{th}	4.14 to 5.76	5.21	13.01% to 16.06%	14.41%
70^{th} to 80^{th}	5.76 to 6.83	6.28	16.06% to 20.93%	18.16%
80^{th} to 90^{th}	6.83 to 7.89	7.29	20.93% to 32.62%	25.14%

Data

Risk of 5% Inflation

The data suggest that in the 5-year time frame, increased productive capacity reduces the risk of inflation and increased government expenditures increase the risk of inflation. As shown in Tables 1, data points with inflation greater than 5% events are more common when government expenditures increase significantly and when Resource Scores are low. In Table 1, Resource Scores increase as you go down the table, and government expenditures increase as you go across the table towards the right.

My hypothesis predicts that high inflation should be more common in the upper right corner of the table and less common in the lower left because the upper right corner represents data points for countries with very low resource scores that greatly increased government expenditures. Conversely, the lower left corner represents data points for countries with very high resource scores that increased government expenditures by a small amount. Table 1 validates the hypothesis. The color-coding scheme in the table, with red representing a greater chance of high inflation and blue representing a smaller chance of high inflation, illustrates this, since blue is clustered in the bottom left and red in the upper right. The R-G combinations with fewer than 5 total data points (the "small sample size variables") shaded in grey.

Chart 1 shows the correlation between the predicted risk of 5% inflation from the model and the actual risk of 5% inflation, after excluding the small sample size variables. I ran a bivariable regression using the inputs from both the average Resource Score and average growth in government expenditure for each set of data points, which produced the following coefficients and P-values.

	Coefficients	*P-value*
Intercept	0.466	3.14E-09
Resource Score	-0.066	7.10E-09
Growth in Government Expenditure	2.151	9.98E-08

The near-zero P-values indicate a very high statistical significance and replicability for the strength and direction of each coefficient. The full equation for I=5% is P(I) = -.066R + 2.151G + .466. The R-squared value for the entire correlation between predicted and actual risk of inflation under the model is 0.7809, meaning that the model explains over three quarters of the variation between predicted and actual inflation above 5%. The regression coefficient for R indicates that if government expenditures are constant, an increase in Resource Score of 1 decreases the chance of experiencing inflation above 5% by 6.6 percentage points. The regression coefficient for G indicates that if Resource Scores are held constant, an increase in government expenditures of 100% increases the chance of experiencing inflation above 5% by 215.1 percentage points, or put more simply, an increase in government expenditures of 1% increases the chance of experiencing inflation above 5% by 2.151 percentage points.

Count	RS Average									
		Count	77	77	78	77	77	78	77	77
		GE Average	1.16%	3.98%	6.16%	8.58%	11.40%	14.41%	18.16%	25.14%
Count	RS Average	**I = 5%**								
77.00	0.40	Inflation > I	20	0	0	4	10	4	7	8
		Total	21	0	1	6	12	7	8	8
		Percentage	95%	--	0%	67%	83%	57%	88%	100%
77.00	0.73	Inflation > I	2	2	5	5	4	4	5	10
		Total	2	5	10	9	7	6	5	11
		Percentage	100%	40%	50%	56%	57%	67%	100%	91%
78.00	1.40	Inflation > I	2	1	1	3	5	9	7	10
		Total	2	1	4	4	9	13	8	14
		Percentage	100%	100%	25%	75%	56%	69%	88%	71%
77.00	2.07	Inflation > I	0	1	1	4	7	7	7	11
		Total	0	2	2	10	11	10	11	13
		Percentage	--	50%	50%	40%	64%	70%	64%	85%
77.00	3.46	Inflation > I	3	1	0	1	4	4	12	10
		Total	4	4	4	6	8	8	15	11
		Percentage	75%	25%	0%	17%	50%	50%	80%	91%
78.00	5.21	Inflation > I	1	2	1	1	6	3	4	2
		Total	7	21	13	5	10	6	4	2
		Percentage	14%	10%	8%	20%	60%	50%	100%	100%
77.00	6.28	Inflation > I	1	4	3	1	0	1	3	2
		Total	9	13	11	7	8	2	6	4
		Percentage	11%	31%	27%	14%	0%	50%	50%	50%
77.00	7.29	Inflation > I	0	0	2	5	1	3	1	1
		Total	6	14	14	17	5	7	3	2
		Percentage	0%	0%	14%	29%	20%	43%	33%	50%

Table 1: Probability of Inflation Greater than 5% for given Resource Score and Government Expenditure Bands

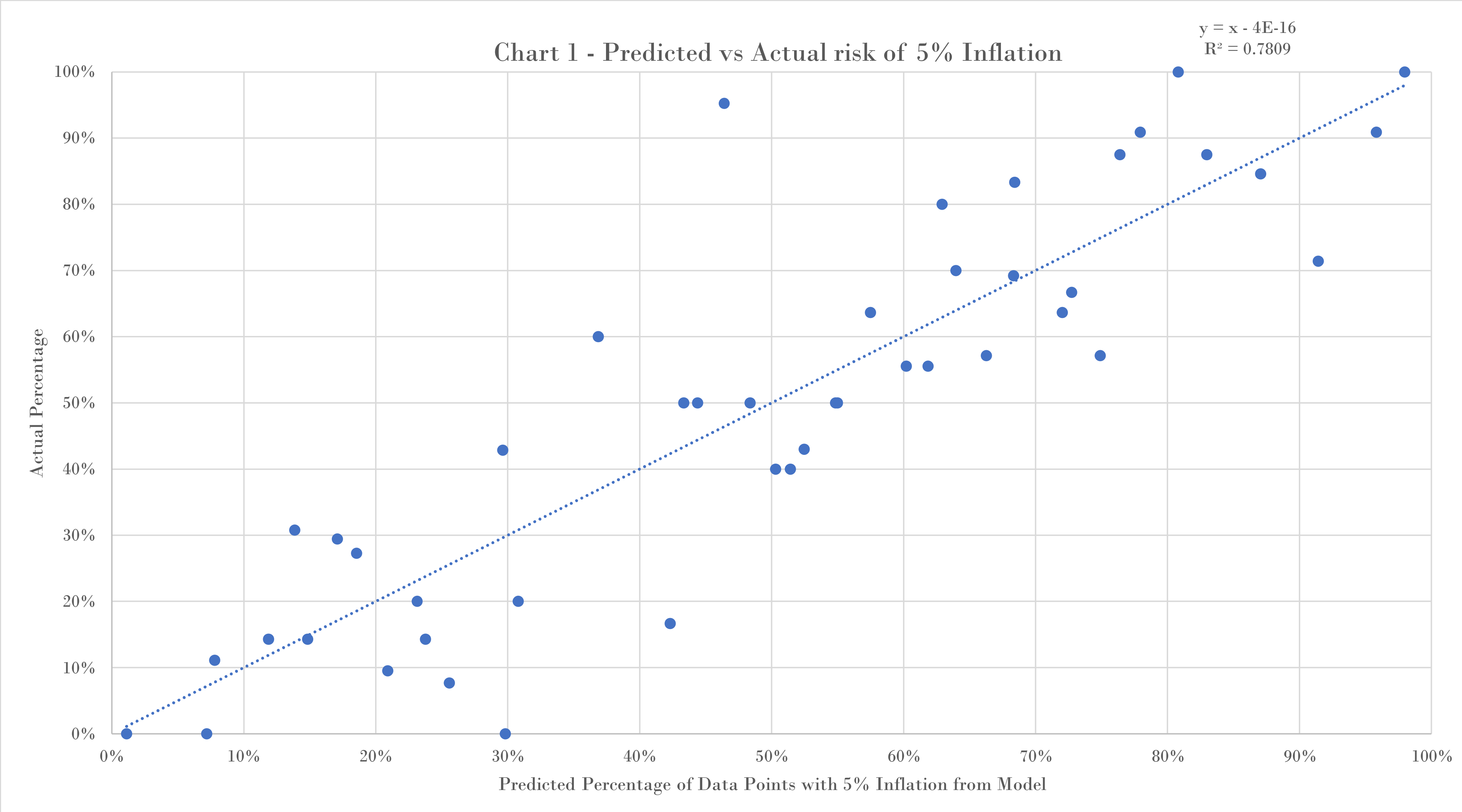
Chart 1 - Predicted vs Actual risk of 5% Inflation
y = x - 4E-16
R² = 0.7809
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Actual Percentage
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Predicted Percentage of Data Points with 5% Inflation from Model

Risk of 10% Inflation

Similarly to the 5% inflation threshold, the data suggests that increased productive capacity reduces the risk of inflation above 10% and increased government expenditures increase the risk of inflation above 10%. As shown in Tables 2, data points with inflation greater than 10% events are more common when government expenditures are increase significantly and Resource Scores are low.

Chart 2 shows the correlation between the predicted risk of 10% inflation from the model and the actual risk of 10% inflation, after excluding the small sample size variables. I ran a bivariable regression using the inputs from both the average Resource Score and average growth in government expenditure for each set of data points, which produced the following coefficients and P-values.

	Coefficients	*P-value*
Intercept	0.131	0.0836
Resource Score	-0.034	0.0027
Growth in Government Expenditure	1.640	0.0002

The near-zero P-values indicate a very high statistical significance and replicability for the strength and direction of each coefficient. The full equation for I=10% is $P(I) = -.034R + 1.640G + .131$. The R-squared value for the entire correlation between predicted and actual risk of inflation under the model is 0.5086, meaning that the model explains over half of the variation between predicted and actual inflation above 10%. The regression coefficient for R indicates that if government expenditures are constant, an increase in Resource Score of 1 decreases the chance of experiencing inflation above 10% by 3.4 percentage points. The regression coefficient for G indicates that if Resource Scores are held constant, an increase in government expenditures of 100% increases the chance of experiencing inflation above 10% by 164.0 percentage points, or put more simply, an increase in government expenditures of 1% increases the chance of experiencing inflation above 10% by 1.640 percentage points.

		Count	77	77	78	77	77	78	77	77
		GE Average	1.16%	3.98%	6.16%	8.58%	11.40%	14.41%	18.16%	25.14%
Count	RS Average	**Inflation > 10%**								
77.00	0.40	Numerator	13	0	0	1	1	0	1	5
		Denominator	21	0	1	6	12	7	8	8
		Percentage	62%	--	0%	17%	8%	0%	13%	63%
77.00	0.73	Numerator	1	0	1	1	2	4	3	7
		Denominator	2	5	10	9	7	6	5	11
		Percentage	50%	0%	10%	11%	29%	67%	60%	64%
78.00	1.40	Numerator	1	1	0	1	2	3	4	6
		Denominator	2	1	4	4	9	13	8	14
		Percentage	50%	100%	0%	25%	22%	23%	50%	43%
77.00	2.07	Numerator	0	1	0	1	1	2	6	10
		Denominator	0	2	2	10	11	10	11	13
		Percentage	--	50%	0%	10%	9%	20%	55%	77%
77.00	3.46	Numerator	0	0	0	0	0	1	5	5
		Denominator	4	4	4	6	8	8	15	11
		Percentage	0%	0%	0%	0%	0%	13%	33%	45%
78.00	5.21	Numerator	0	1	1	0	0	2	0	2
		Denominator	7	21	13	5	10	6	4	2
		Percentage	0%	5%	8%	0%	0%	33%	0%	100%
77.00	6.28	Numerator	1	1	0	0	0	0	2	1
		Denominator	9	13	11	7	8	2	6	4
		Percentage	11%	8%	0%	0%	0%	0%	33%	25%
77.00	7.29	Numerator	0	0	0	0	0	0	0	1
		Denominator	6	14	14	17	5	7	3	2
		Percentage	0%	0%	0%	0%	0%	0%	0%	50%

Table 2: Probability of Inflation Greater than 10% for given Resource Score and Government Expenditure Bands

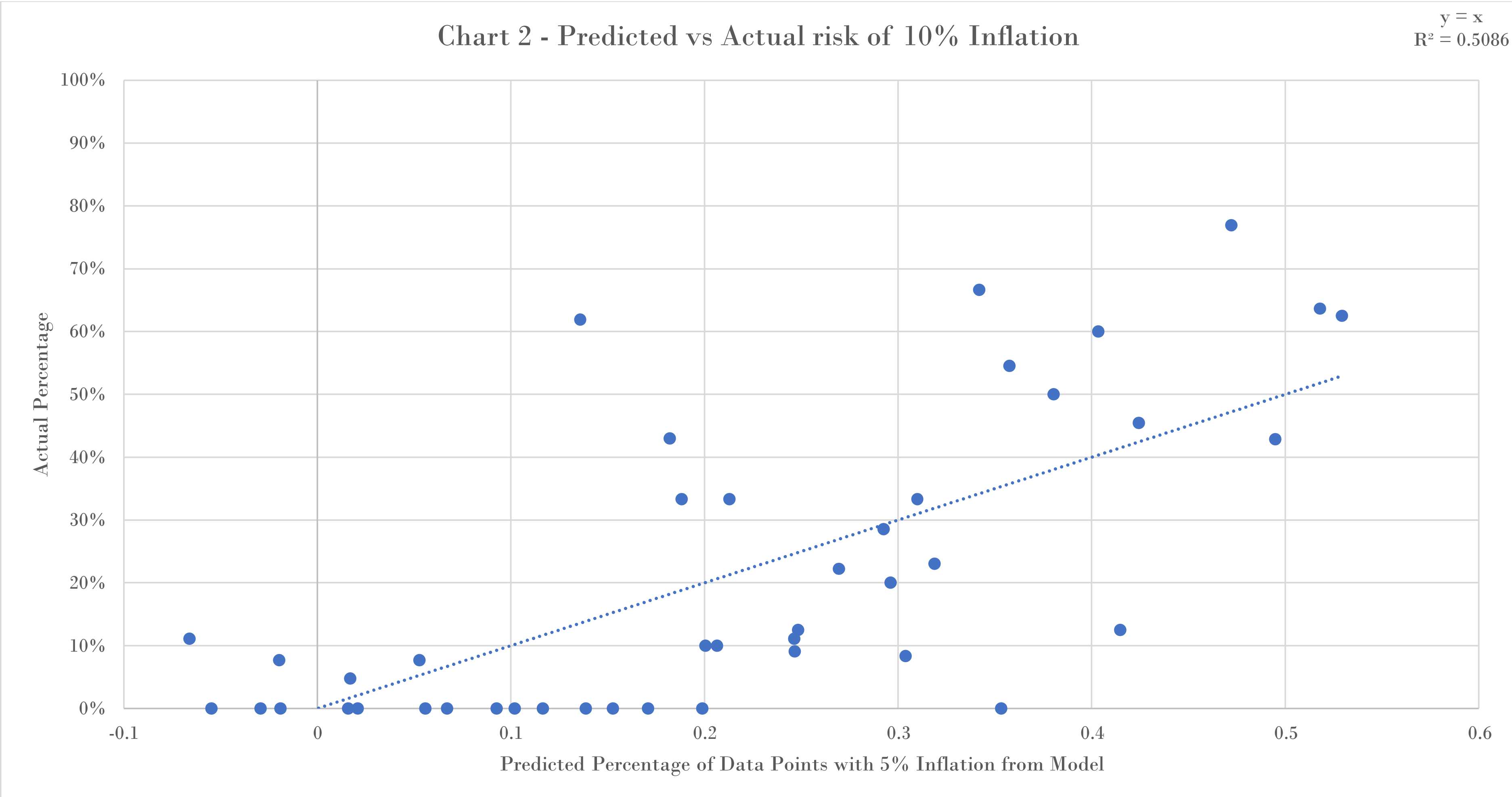
Chart 2 - Predicted vs Actual risk of 10% Inflation
y = x
R² = 0.5086
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Actual Percentage
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
Predicted Percentage of Data Points with 5% Inflation from Model

Hyperinflation

For this paper, I defined hyperinflation as annual inflation of at least 50% per year and sustained hyperinflation as average inflation of at least 50% over a five-year period. These are the countries that experienced hyperinflation in years for which I had data necessary to calculate a Resource Score, either in the immediate year or over the next five years.

Country	**Year**	Inflation	5-year Inflation	GE growth	Resource Score
Argentina	1991	171.7%	35.8%	184.84%	2.65
Iceland	1981	51.8%	45.2%	59.00%	6.48
Iceland	1982	50.2%	39.6%	63.45%	6.32
Iceland	1983	84.0%	35.5%	84.20%	5.97
Indonesia	1998	58.5%	16.9%	58.27%	0.93
Mexico	1981	27.9%	66.4%	58.48%	2.43
Mexico	1982	58.9%	83.7%	181.18%	2.42
Mexico	1983	101.9%	92.9%	72.62%	2.25
Mexico	1984	65.4%	79.2%	46.20%	2.29
Mexico	1985	57.7%	72.8%	78.47%	2.33
Mexico	1986	86.2%	66.9%	99.12%	2.15
Mexico	1987	131.8%	55.1%	171.08%	2.17
Mexico	1988	114.2%	34.8%	76.79%	2.16
Nigeria	1993	57.2%	39.1%	36.29%	0.75
Nigeria	1994	57.0%	30.7%	-14.94%	0.69
Nigeria	1995	72.8%	22.4%	21.42%	0.66
Russian Federation	1995	197.4%	59.1%	0.00%	2.83
Russian Federation	1999	85.7%	28.1%	48.59%	2.76
Turkey	1985	45.0%	51.8%	52.17%	1.33
Turkey	1986	34.6%	55.3%	18.94%	1.45
Turkey	1987	38.9%	61.2%	54.57%	1.48
Turkey	1988	68.8%	65.8%	72.90%	1.51
Turkey	1989	63.3%	71.8%	82.56%	1.47
Turkey	1990	60.3%	76.1%	76.49%	1.57
Turkey	1991	66.0%	79.5%	101.58%	1.56
Turkey	1992	70.1%	82.8%	70.22%	1.59
Turkey	1993	66.1%	85.2%	120.34%	1.65
Turkey	1994	105.2%	75.2%	86.68%	1.56
Turkey	1995	89.1%	59.1%	91.70%	1.65
Turkey	1996	80.4%	45.3%	128.60%	1.74
Turkey	1997	85.7%	33.4%	113.80%	1.82
Turkey	1998	84.6%	20.4%	97.72%	1.87
Venezuela	1989	84.5%	48.3%	-27.66%	5.48

Country	Year	Inflation	5-year Inflation	GE growth	Resource Score
Venezuela	1990	40.7%	44.2%	6.42%	5.71
Venezuela	1991	34.2%	54.1%	17.01%	5.99
Venezuela	1992	31.4%	56.7%	2.34%	5.96
Venezuela	1993	38.1%	57.4%	-10.52%	5.91
Venezuela	1994	60.8%	55.0%	48.73%	5.83
Venezuela	1995	59.9%	47.6%	3.31%	6.06
Venezuela	1996	99.9%	39.7%	-23.14%	6.03
Venezuela	1997	50.0%	26.8%	35.75%	6.33
Venezuela	2011	26.1%	87.8%	32.00%	5.06
Zimbabwe	2006	1096.7%	4252.4%	-50.99%	0.39
Zimbabwe	2007	24411.0%	4070.2%	-42.73%	0.35

Discussion and Conclusions

There are three conclusions that the model suggests. The first is that austerity is not the cure for inflation in resource poor countries. In both the 5% and 10% inflation samples, the poorest countries that did not increase their government expenditures still had a very high probability of experiencing inflation. Countries with a Resource Score in the 10-20th percentile had a 95% chance of experiencing inflation above 5%, even when government expenditures increased by 2.66% or less. Similarly, countries with a Resource Score in the 10-20th percentile had a 62% chance of experiencing inflation above 10% with the same values of government expenditures. The possible reason for this is that when government expenditures in resource-poor countries are very low, this relative lack of fiscal stimulus leads to low aggregate demand, which discourages businesses from expanding productive capacity.

The second is that there appear to be clear thresholds for production and government expenditure after which high levels of inflation are highly unlikely to occur, as the model and intuition would predict. When government expenditures increase by 8.58% or less at a Resource Score of 5.21 or higher, which indicates that the country produces 174% of the food, energy, and manufactured goods necessary for its population to maintain a high standard of living, inflation above 5% occurs *at most* 29% of the time. Similarly, when government expenditures increase by 11.40% or more at a Resource Score of 3.46 or less, inflation above 5% occurs *at least* 57% of the time. Similarly, when the Resource Score is 5.21 or higher and government expenditures increase by 11.40% or less, inflation of 10% or more happens at *most* 11% of the time.

The third is that there is a specific level of production at which sustained hyperinflation (defined here as average annual inflation greater than 50% over a 5 year period) is virtually impossible. The sample contains five countries that experienced sustained hyperinflation: Mexico, Russia, Turkey, Venezuela, and Zimbabwe. Contrary to claims that these were economically advanced countries that were ruined by loose fiscal and monetary policy, examining their Resource Scores paints a much more impoverished picture of their economies.

Among the countries that experienced sustained hyperinflation at any point during the study, the only country that *ever* attained Resource Score over 3 were Russia and Venezuela. However, all of Russia's periods of sustained hyperinflation came before it ever attained a Resource Score of 3. Venezuela is the only country to experience sustained hyperinflation while also posting a Resource Score above 3. One possible explanation for this is that smuggling and government corruption have prevented food, energy, and manufactured goods from entering the economy outside of black market sales. Venezuela claims that 40% of its commodities are smuggled out of the country, and corruption in the Venezuelan government is a widely known issue.[xxi]

There are several opportunities for further research on this topic. First, further research could investigate if the technological complexity of the output of manufactured goods significantly affects inflation risk reduction. Second, further research could also investigate the effect of commodity buffer stock programs on stimulating investment in productive capacity. Third, further research could investigate whether exporting critical goods or providing them to tourists diminishes the risk-reduction effect of producing those goods. This area of economics has been widely neglected, but this model can be used as a guiding point for further policy-oriented research.

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[ix] *Id.* at pp. 28-30.

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