Project Report - Elasticity Study For International Voice Calls

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1. Introduction and Motivations

The market for international voice calls has changed rapidly over the last two decades; several factors have contributed to this fast paced change, and throughout the rest of this section we will explore some of them. Because the issue of International Voice Calls (IVCs) is very complex, we chose to narrow our research to two areas that we believe have had the greatest impact on the IVC market: immigration to the US, and new technologies.

First, lets begin exploring the issue related to the immigrant population in the US. As we can see in **Figure 1.1**, the immigrant population in the US is increasing at a tremendous pace, going from roughly 5% of the entire population in 1990, to about 14% at the beginning of 2010.

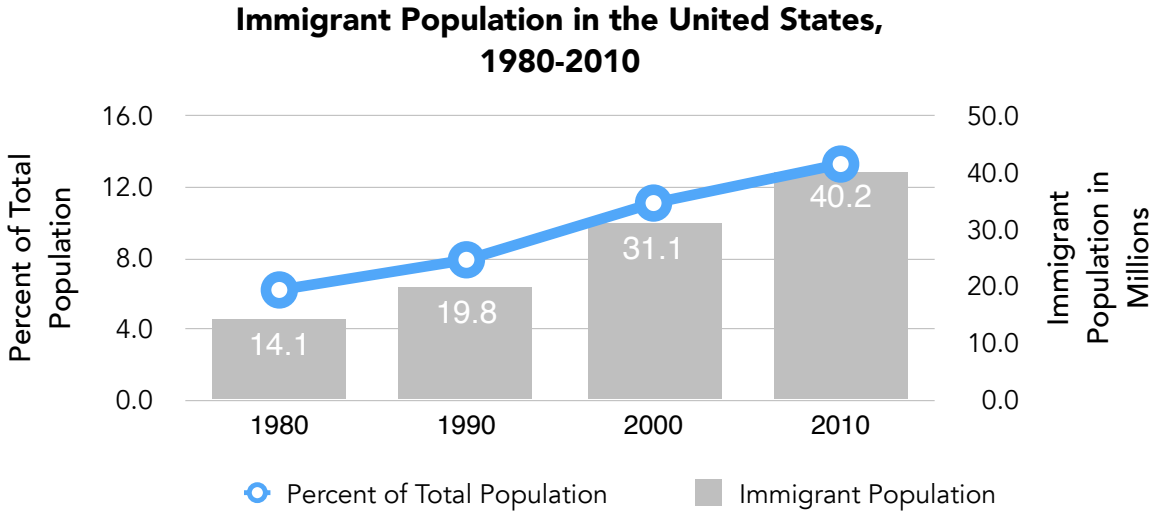


Figure 1.1: Immigrant Population in the United States, 1980-2010

This growth is remarkable and there is no indication that it will begin to flatten. In order to help us establish the relationship that exists between immigration and the demand for IVCs, let's proceed and take a look at **Figure 1.2** that shows the number of immigrants by Region.

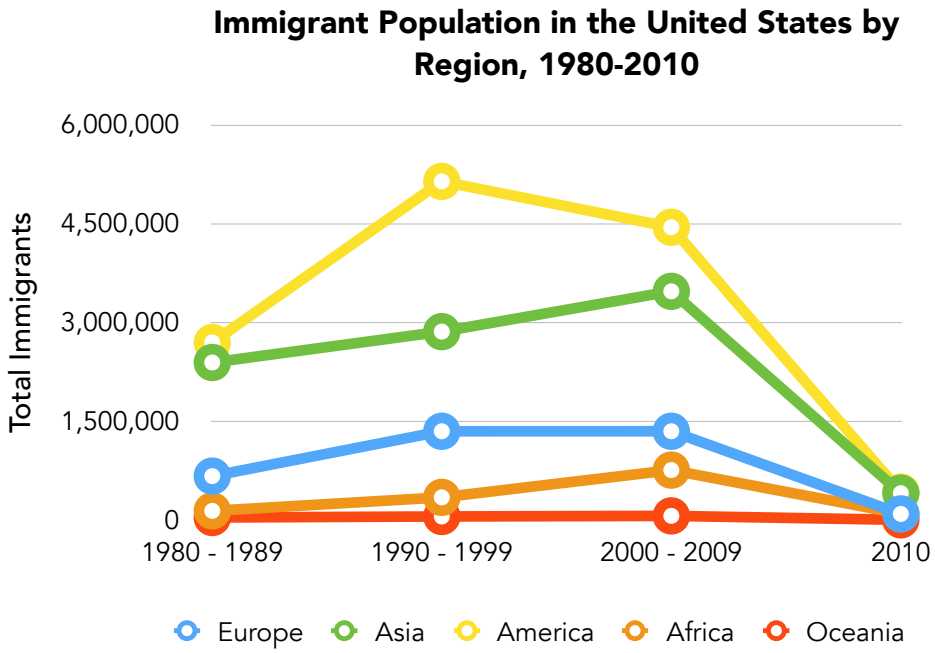


Figure 1.2: Immigrant Population in the United States by Region, 1980-2010

Several interesting facts can be taken from the previous graph. We can see that from 1980 until 2009, the two regions with the biggest influx of immigrants were America and Asia, followed by Europe. When comparing these values, to those shown in **Figure 1.3**, we can see that there is a clear correlation between the number of total immigrants per year, and the total number of minutes consumed from the US to other countries over the same span of time. As more immigrants came to the US more minutes where consumed, meaning that there exists a proportional relationship between immigration and the demand for IVCs.

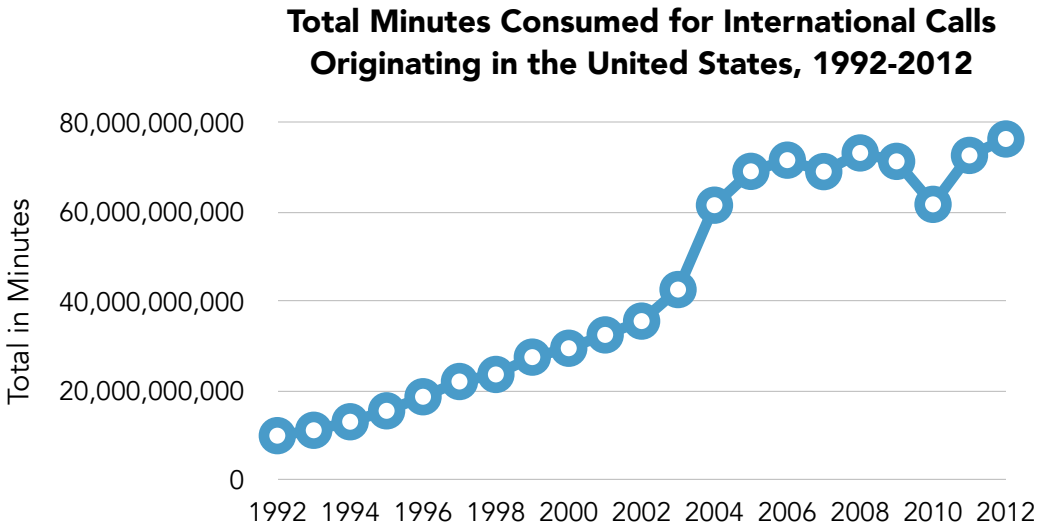


Figure 1.3: Total Minutes Consumed for International Calls Originating in the United States, 1992-2012

Although, both the traffic volume and service providers revenue have increased dramatically over the last two decades, new widely adopted technologies are disrupting the IVCs industry at an unimaginable pace. We are referring to VoIP — Voice Over IP — and the Smartphone Penetration in the US and the World, issues that we will now explore.

The emergence of VoIP (Voice over IP) technology has changed the market structure significantly over the last years. The popularity of Skype, and other IP-based international calling options not only has decreased the market price of traditional international calling, but also has taken market share away from the telecommunication international minutes. This can be attributed, from an opportunity-cost perspective, to the fact that VoIP provided the same QoS as traditional land-lines, at a reduced cost for the customer. Also, if we assume that the majority of the IVCs market is comprised of immigrants, then it is also justified the use of a cheaper service as usually lack the financial stability and resources.

Now lets see how VoIP has affected the demand for IVCs. According to TeleGeography, the total international voice traffic grew nine percent in 2011, to 467 billion minutes, however, traditional time division multiplexed (TDM) international traffic grew only three percent, to 317 billion minutes, while traffic carried as Voice over IP (VoIP) grew 25 percent, to 150 billion minutes. Due to increasing competition, average prices have fallen at a compounded rate of approximately eight percent annually since 2002, although the traffic grew rapidly enough to offset these steady price declines until 2008, after which, the revenue remained relatively flat, ending with $13.2 billion in 2011. **This being said, in our research, we will focus exclusively on the demand of traditional time division multiplexed (TDM) international calls.**

The Global Traffic Map, shown in Figure 1.4 and taken from TeleGeography Report research[1], illustrates the traffic of voice telecommunications between countries on a global scale:

Figure 1.4: Global Traffic Map

As can be seen, the majority of the market for IVCs in the US is concentrated in coastal cities and metropolitan areas and is driven by higher levels of globalization that the society has experienced in the last few decades. It should be noted that historically, coastal cities have been portrayed as the centers for economical activities, and have thus, a more diverse population.

Figure 1.5 illustrates the trend in traffic for the IVCs market, and it includes both the VoIP and TDM traffic, along with the growth rate for TDM. Since the emergence of VoIP, the growth of TDM traffic has slowed significantly while that of VoIP continued to increase dramatically over the span of ten years since its public inception in the year 200. However, although the growth rate has decreased, the overall trend of call volume for TDM has increased approximately six times over that short span of time meaning that although VoIP can in the long run hurt the industry, it has still not done so.

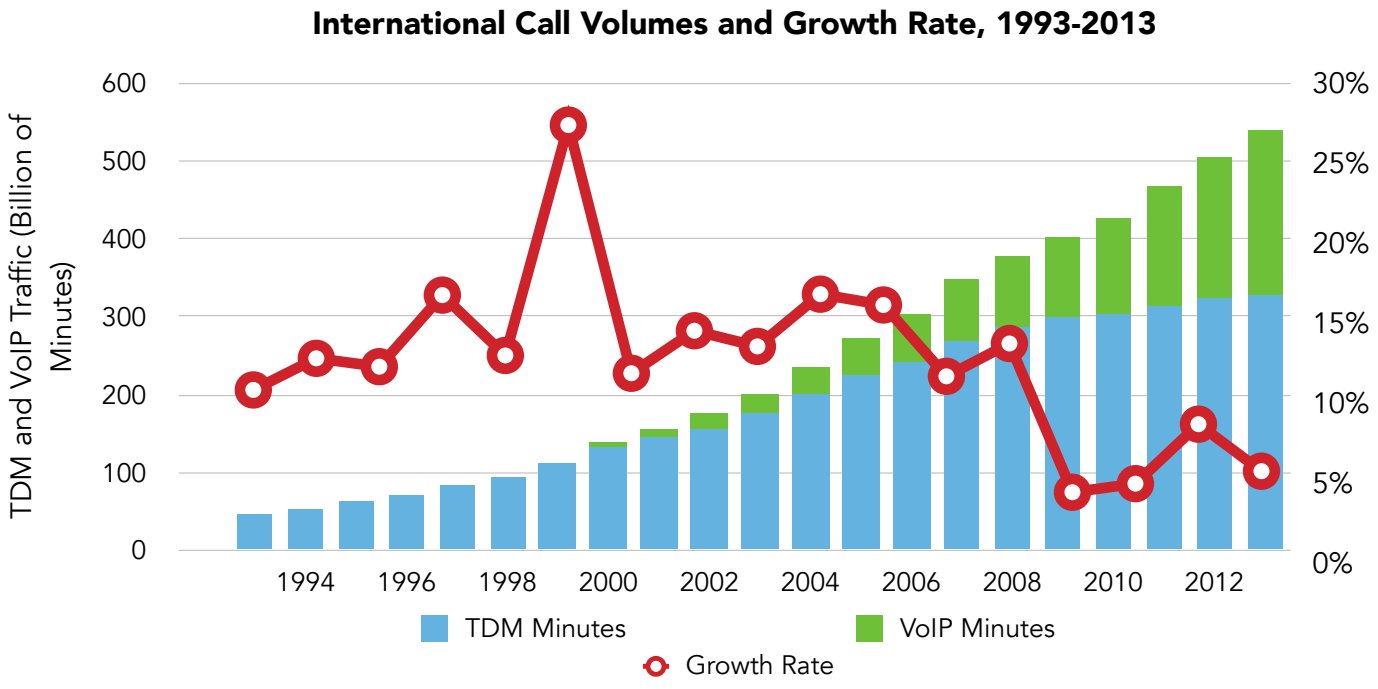


Figure 1.5: International Call Volumes and Growth Rates

Along with the issues previously explained, in the last decade there is another technological innovation that is changing the game for the IVCs market. With the introduction of Smartphones, the issue of asymmetrical telecommunications between the world and the US is starting to shift towards a less asymmetrical model, as these devices has seen great adoption both locally and globally. In order to support this statement, let's consider the data portrayed in **Figure 1.6** and **Figure 1.7.**

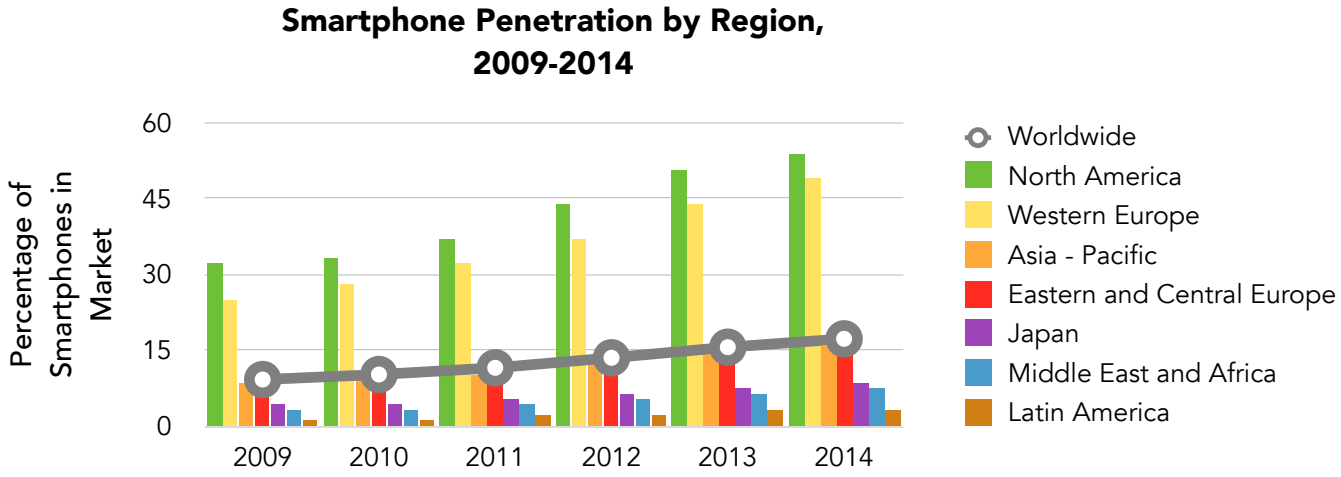


Figure 1.6: Smartphone Penetration by Region

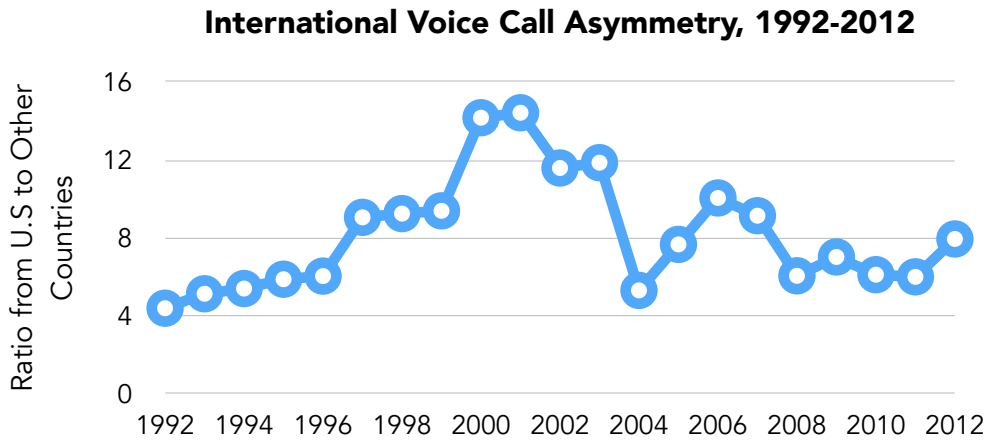


Figure 1.7: International Voice Call Asymmetry

We can clearly see from these graphs that there is a trend for mass adoption of smartphones, and we can also see how it is affecting the asymmetry of communications leaving the US. According to Mark Uretsky, the mass adoption of smartphones in other countries, "particularly poor countries, as this has made calling back home feasible for the first time." Previously most of the international calls were outbound, while recently there is more and more inbound calls, meaning that the asymmetric ratios will decrease. This is confirmed by our computations displayed in Figure 1.7, where we used data from the FCC to compute the ratio as follows: (Number of Outbound Minutes) / (Number of Inbound Minutes).

Now that we have stated our motivations, and have listed some of the possible factors that can affect IVCs, let's proceed to define the model we are going to be using in order to compute the elasticities of demand against all the previously mentioned factors.

2. Model

For each of the following regressions, we will be using a Log-Log Regression model in order to compute the elasticities for the given independent and dependent variables.

i. Regression I: Quantity vs. Price Elasticity

$$\log Q = \beta 0 + \beta 1 * \log \text{Price} + \varepsilon$$

Where Q represents the total number of minutes over that period in time, Price is the price per minute from calls originating in the US, and the error term captures all other factors that we did not include in our model.

ii. Regression II: Quantity vs. Price and Foreign GDP

$$\log Q = \beta 0 + \beta 1 * \log \text{Price} + \beta 2 * \log \text{GDP} + \varepsilon$$

Where Q represents the total number of minutes over that period in time, Price is the price per minute from calls originating in the US, GDP is the GDP of the destination country, and the error term captures all other factors that we did not include in our model.

iii. Regression III: Quantity vs. Immigration Population

$$\log Q = \beta 0 + \beta 1 * \log \text{Immigration} + \varepsilon$$

Where Q represents the total number of minutes over that period in time, Immigration is the total number of immigrants for a given year from the destination country, and the error term captures all other factors that we did not include in our model.

iv. Regression IV: Quantity vs. Asymmetry and Price

$$\log Q = \beta 0 + \beta 1 * \log \text{Asymmetry} + \beta 2 * \log \text{Price} + \varepsilon$$

Where Q represents the total number of minutes over that period in time, Asymmetry is the ratio of outbound minutes to inbound minutes from US to destination country, Price is the price per minute from calls originating in the US, and the error term captures all other factors that we did not include in our model.

3. Data

International calls

As guided by the project explanation, all data of international voice calls is collected from FCC official website (http://transition.fcc.gov/wcb/iatd/intl.html). The data does not include traffic for VoIP as pointed out by Mark Uretsky. Data of international voice calls available on FCC site is from 2012 to 1992; hence the data available is all the international voice calls data made from the U.S to 218 countries and regions globally *by year*.

Income

Data of foreign GDP (Gross Domestic Product) is collected from the World Bank, and it includes GDP and associated attributes of 184 countries and regions.

Immigrant population

We use foreign-born population as an indicator of immigrant population. The data is taken from American Community Survey (http://factfinder2.census.gov/)

4. Approach

In order to compute the regression analysis, we decided to build a Python script that parses all of our data tables into objects that we then use to compute each of our regressions, and finally write the results to their appropriate files. This script will be available as an Open Source project, on the following Github Repository:

http://www.github.com/dgarzon/ITEP

5. Results

i. Regression I: Quantity vs. Price Elasticity

Country	**β1 (Price)**	**t1 (Price)**
Brazil	-0.6	-9.69
Canada	-0.44	-8.44
China	-0.59	-10.12
Germany	-0.21	-3.63
Mexico	-0.64	-11.87
Poland	-0.55	-13.99
Vietnam	-0.47	-3.92

As can be seen from the above table, all estimates are significant with high t-values. However, the absolute values are all smaller than 1, which means the demand is price inelastic. The country with the largest price elasticity is Mexico at -0.64 with a high t-value of -11.87. The one with the lowest value is Germany at -0.21 with t-value -3.63. Note that in general, countries with lower GDP tend to have higher price elasticities than those with higher GDP.

ii. Regression II: Quantity vs. Price and Foreign GDP

Country	β1 (GDP)	β2 (Price)	t1 (GDP)	t2 (Price)
Brazil	-0.01	-0.61	-0.07	-7.56
Canada	1.39	0.07	2.73	0.36
China	0.15	-0.5	0.59	-2.96
Germany	-0.84	-0.35	-1.58	-3.31
Mexico	0.68	-0.48	1.5	-4.17
Poland	0.48	-0.35	1.81	-2.97
Vietnam	3.38	1.07	4.36	2.94

In above table, β2 is the estimated price elastic after including foreign GDP in our regression. Note that for Canada, the price elasticity becomes very low and not statistically different from 0 while the coefficient on Canadian GDP is positive and significant. Since costs to call Canada is already very low, it is reasonable that the price might not have an impact on demand. On the other hand, higher Canadian GDP drives costs lower which then increases the call volumes. However, the model does not suggest the foreign GDP have an impact on call volumes for other countries.

iii. Regression III: Quantity vs. Immigration Population

Country	β1 (Population)	t1 (Population)
Brazil	0.54	0.41
Canada	1.91	1.95
China	-1.08	-1.37
Germany	6.19	4.81
Mexico	-3.2	-0.98
Poland	-1.48	-2.41
Vietnam	-2.04	-1.29

Only Germany has significant estimate for immigrant population, which suggest a positive relation between immigrant population and call values. For other countries, the estimates are not significant which might be due to other missing independent variables.

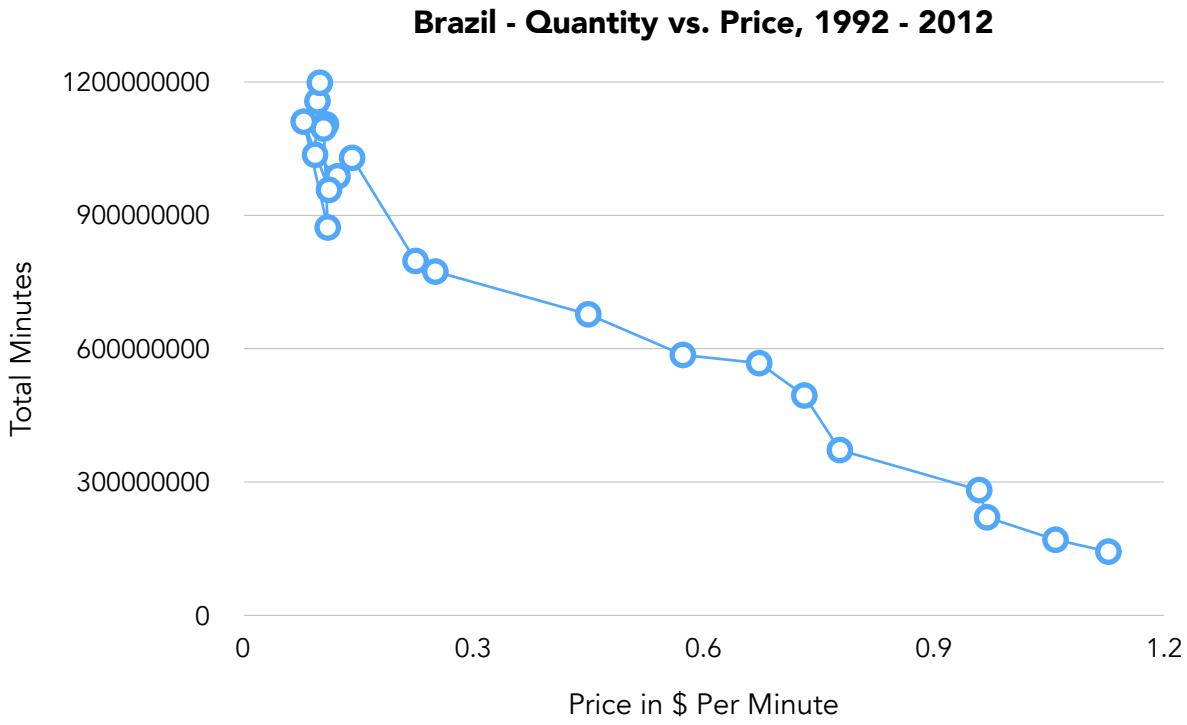
iv. Regression IV: Quantity vs. Asymmetry and Price

Country	**β1 (Symmetry)**	**β2 (Price)**	**t1 (Symmetry)**	**t2 (Price)**
Brazil	-0.73	-0.53	-7.92	-1.75
Canada	-0.38	-0.34	-4.73	-1.0
China	-0.54	0.73	-11.62	3.80
Germany	-0.32	0.52	-4.65	2.43
Mexico	-0.40	0.82	-5.99	4.45
Poland	-0.33	0.40	-6.70	5.10
Vietnam	-0.78	0.78	-5.84	3.36

Now that we have shown the results for all of the regressions we computed, if you wish to see the relevant plots we did for the data gathered, please refer to the Appendix 1.

6. Conclusion

Appendix 1


Brazil - Quantity vs. Price, 1992 - 2012
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900000000
600000000
300000000
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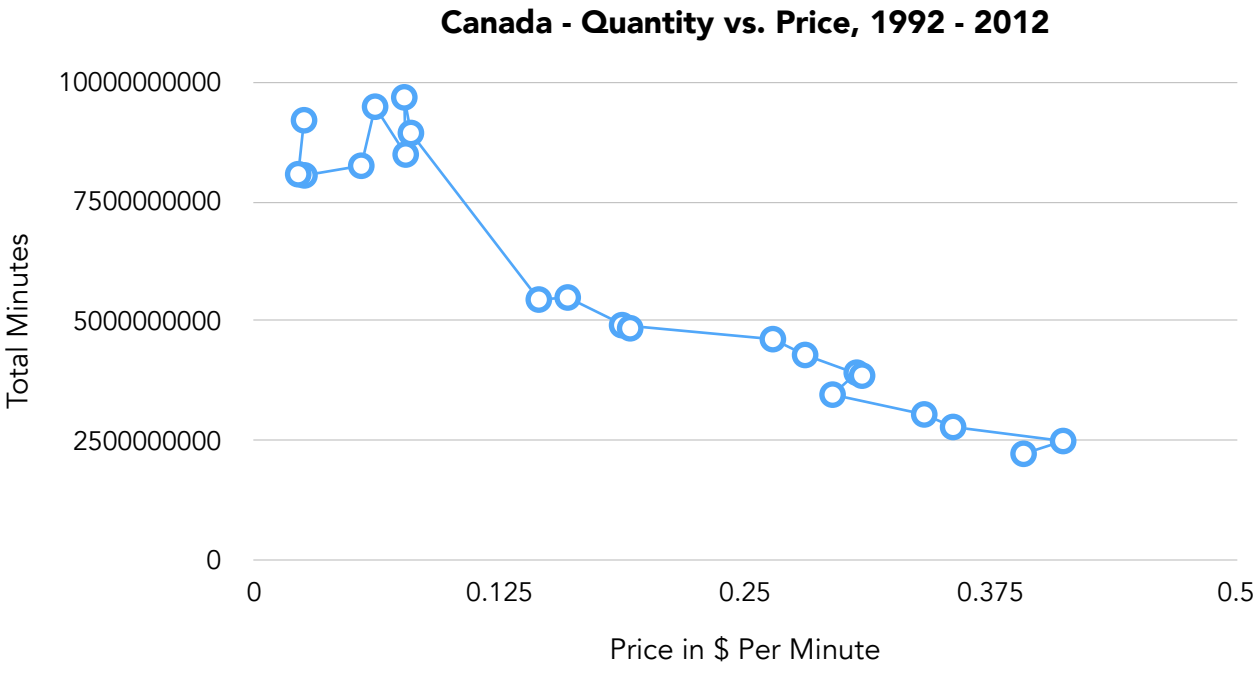
Total Minutes
0
0.3
0.6
0.9
1.2
Price in $ Per Minute


Canada - Quantity vs. Price, 1992 - 2012
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7500000000
5000000000
2500000000
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Total Minutes
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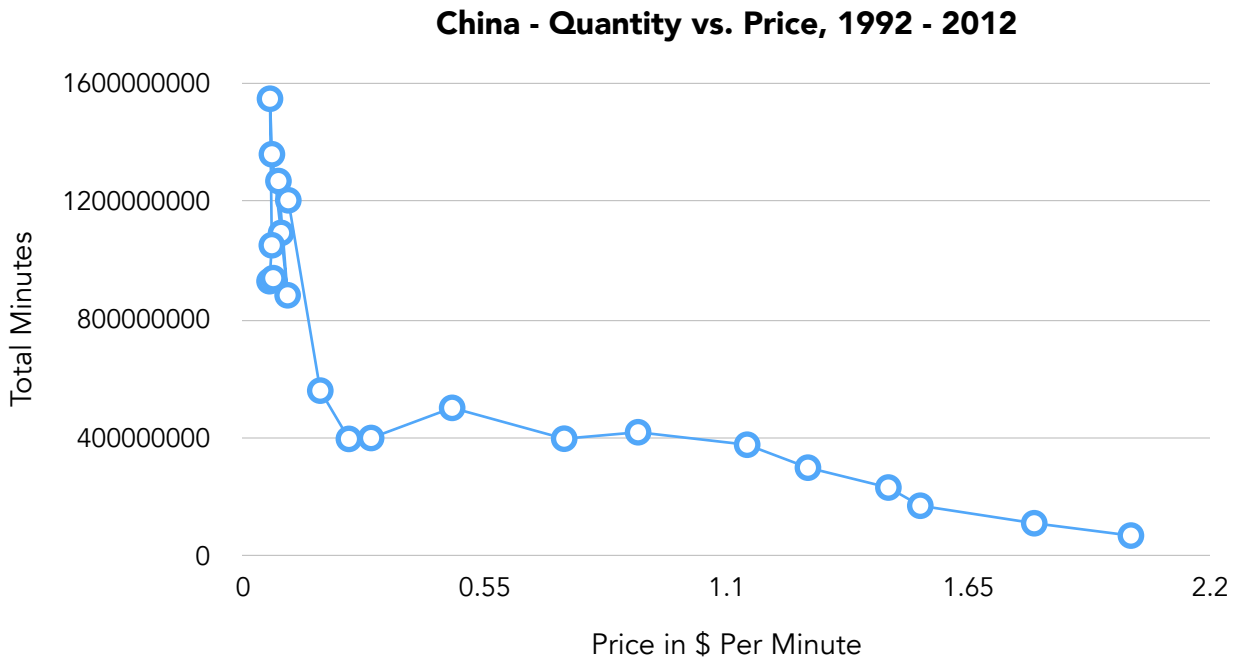
0.125
0.25
0.375
0.5
Price in $ Per Minute


China - Quantity vs. Price, 1992 - 2012
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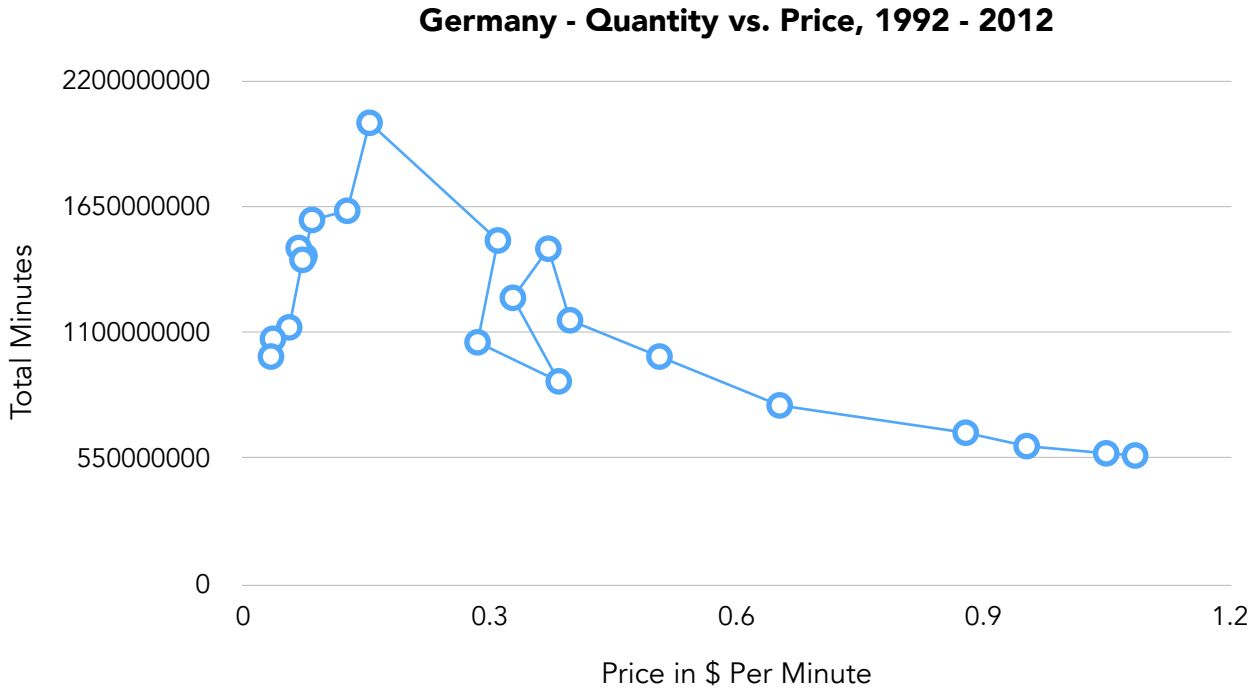
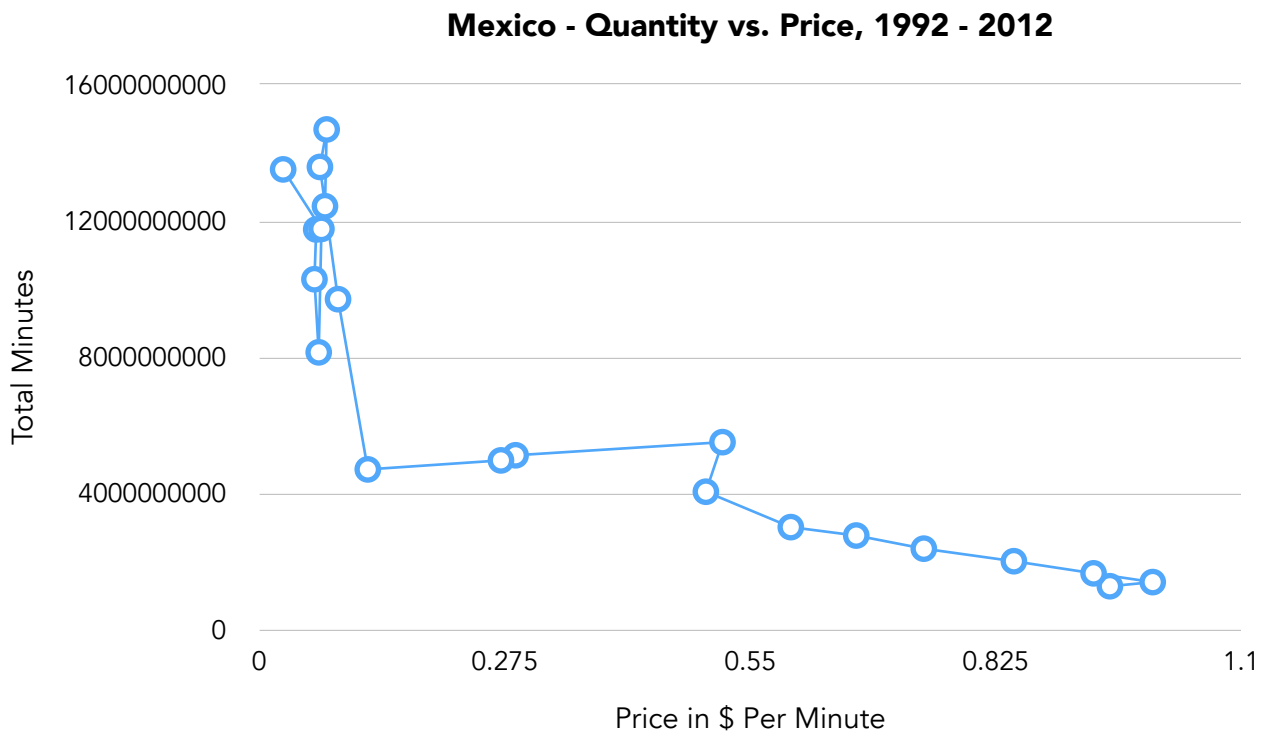
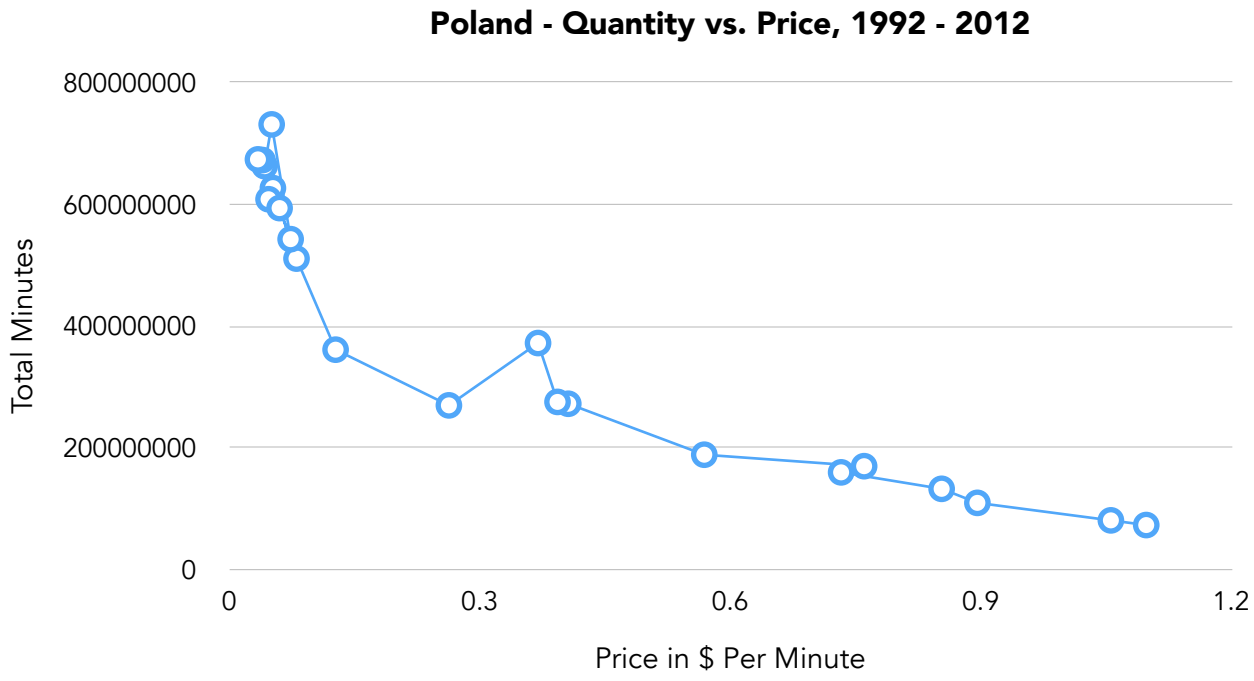
1200000000
800000000
400000000
0
Total Minutes
0
0.55
1.1
1.65
2.2
Price in $ Per Minute


Germany - Quantity vs. Price, 1992 - 2012
2200000000
1650000000
1100000000
550000000
0
Total Minutes
0
0.3
0.6
0.9
1.2
Price in $ Per Minute


Mexico - Quantity vs. Price, 1992 - 2012
16000000000
12000000000
8000000000
4000000000
0
Total Minutes
0
0.275
0.55
0.825
1.1
Price in $ Per Minute


Poland - Quantity vs. Price, 1992 - 2012
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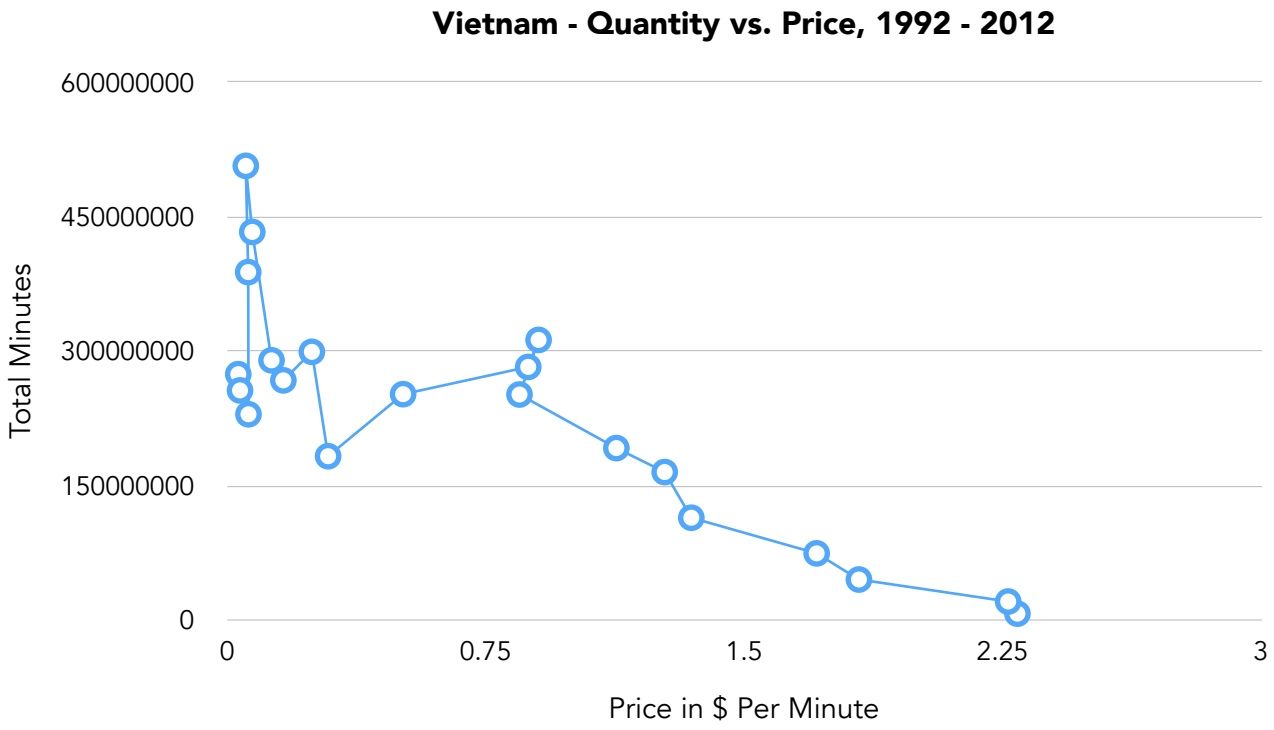
600000000
400000000
200000000
0
Total Minutes
0
0.3
0.6
0.9
1.2
Price in $ Per Minute


Vietnam - Quantity vs. Price, 1992 - 2012
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300000000
150000000
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Total Minutes
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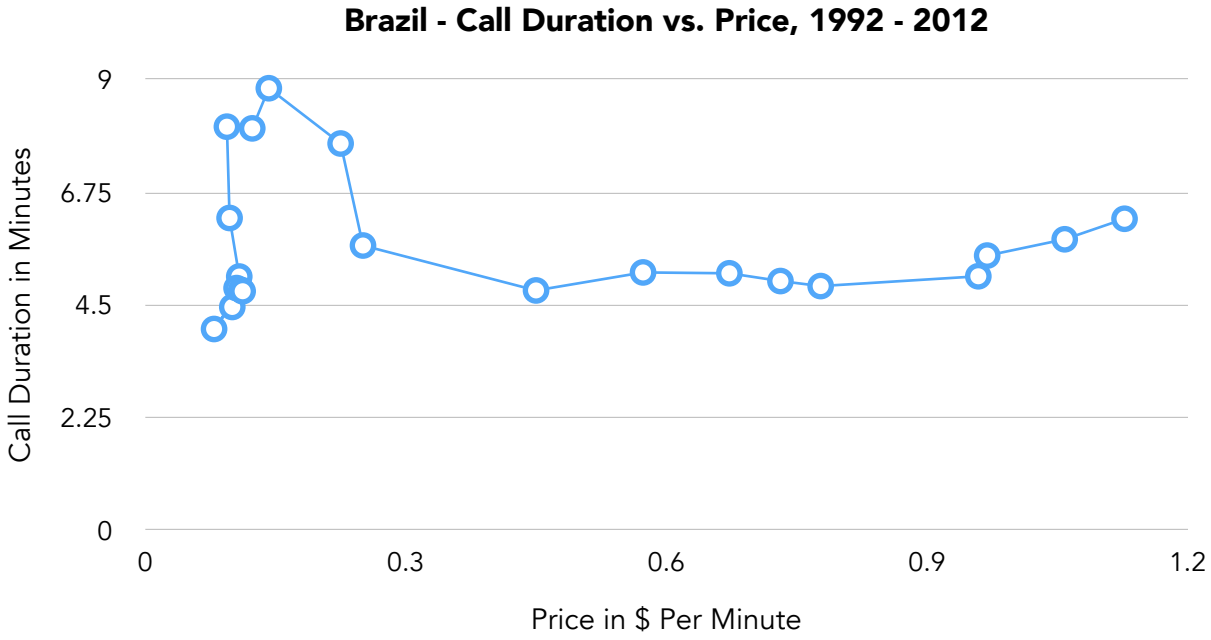
1.5
2.25
3
Price in $ Per Minute


Brazil - Call Duration vs. Price, 1992 - 2012
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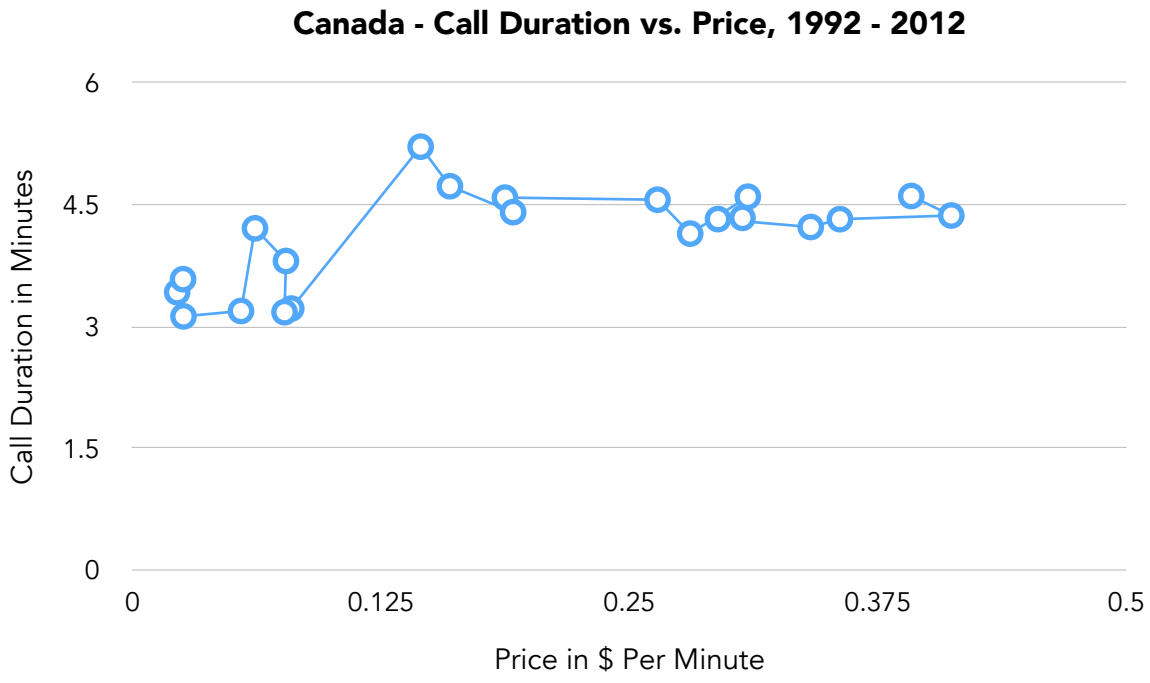
6.75
4.5
2.25
0
Call Duration in Minutes
0
0.3
0.6
0.9
1.2
Price in $ Per Minute


Canada - Call Duration vs. Price, 1992 - 2012
Call Duration in Minutes
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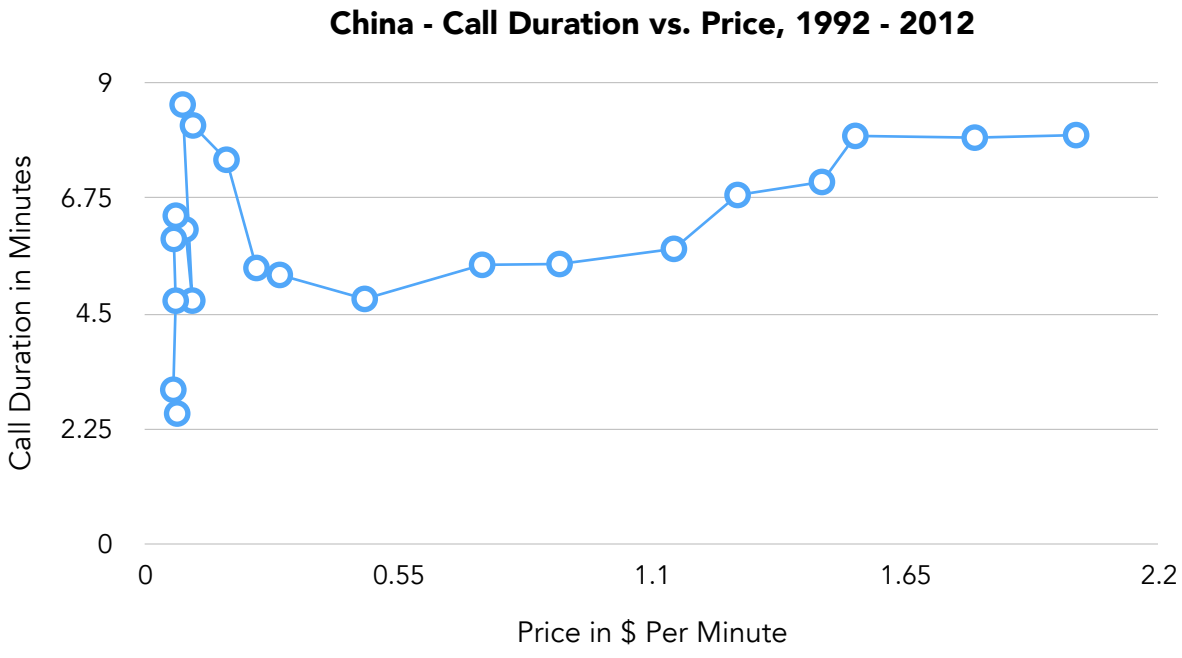
4.5
3
1.5
0
0
0.125
0.25
0.375
0.5
Price in $ Per Minute


China - Call Duration vs. Price, 1992 - 2012
Call Duration in Minutes
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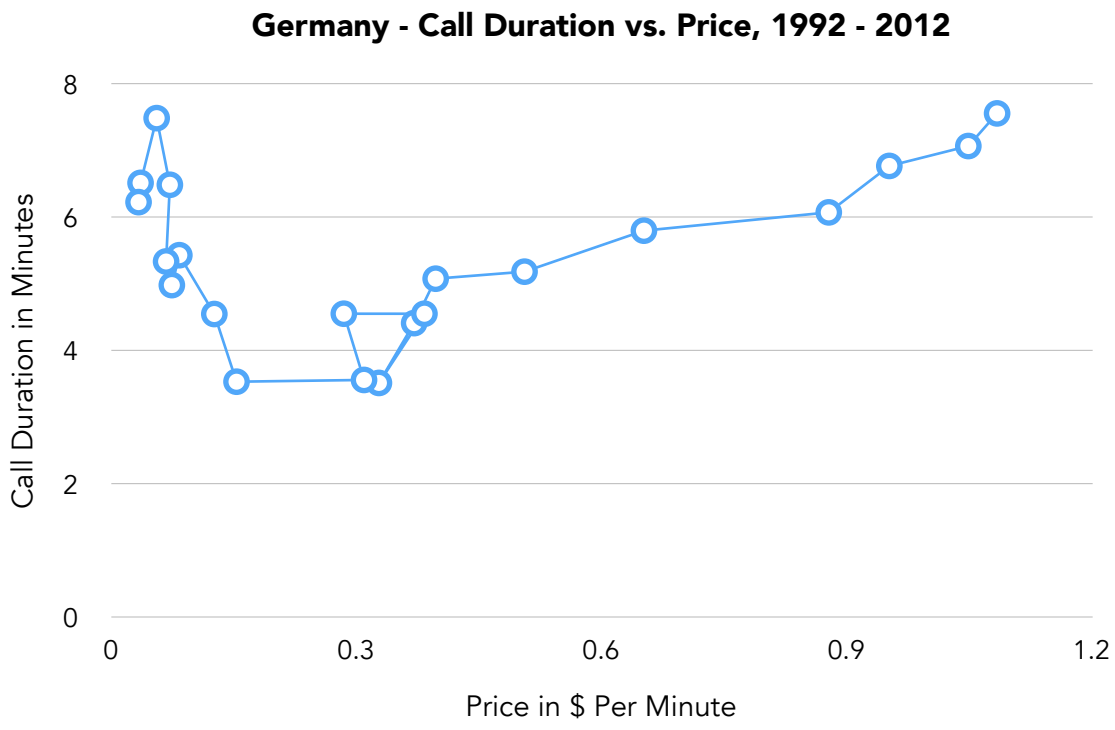
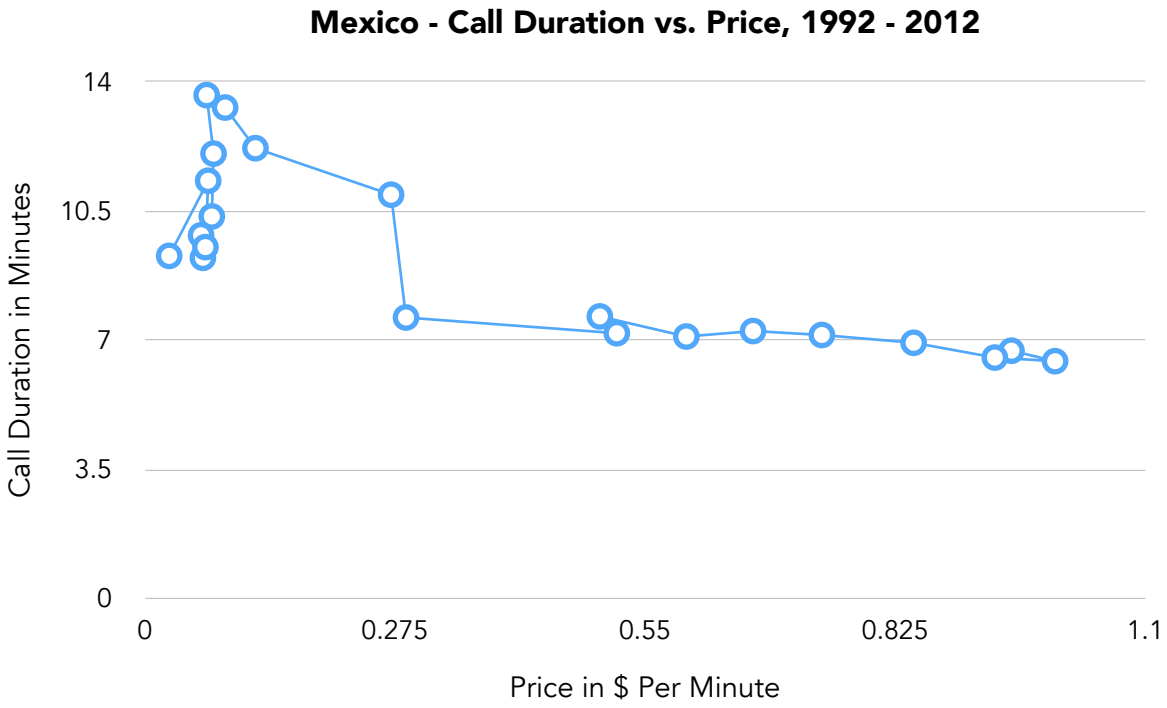
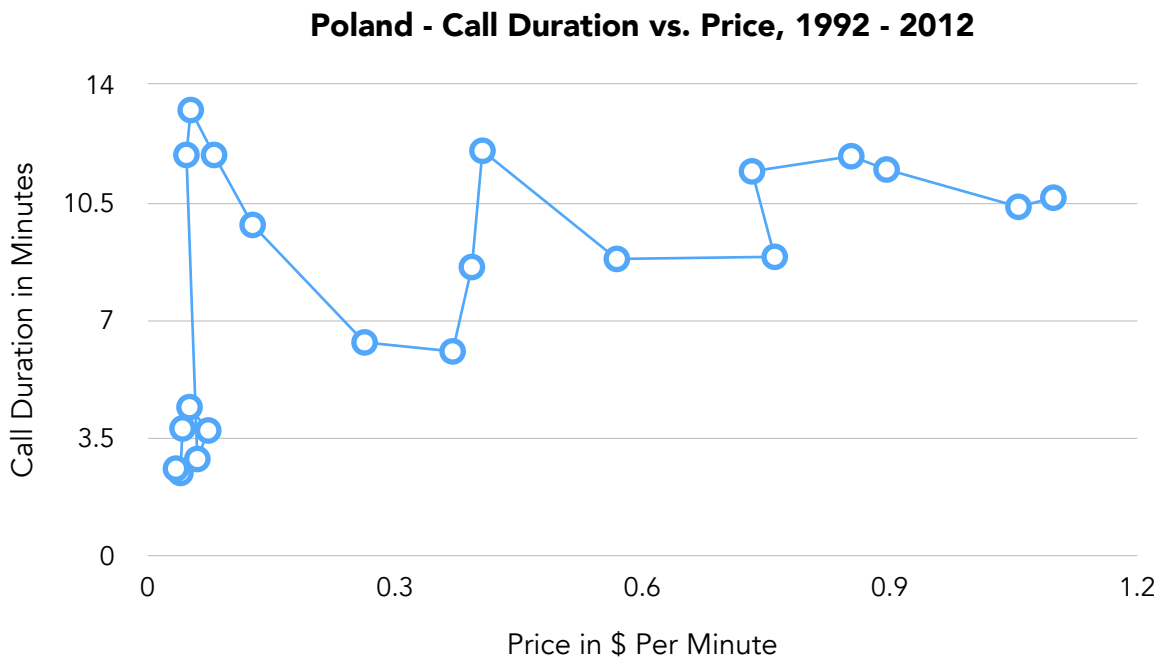
6.75
4.5
2.25
0
0
0.55
1.1
1.65
2.2
Price in $ Per Minute


Germany - Call Duration vs. Price, 1992 - 2012
Call Duration in Minutes
8
6
4
2
0
0
0.3
0.6
0.9
1.2
Price in $ Per Minute


Mexico - Call Duration vs. Price, 1992 - 2012
Call Duration in Minutes
14
10.5
7
3.5
0
0
0.275
0.55
0.825
1.1
Price in $ Per Minute


Poland - Call Duration vs. Price, 1992 - 2012
Call Duration in Minutes
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10.5
7
3.5
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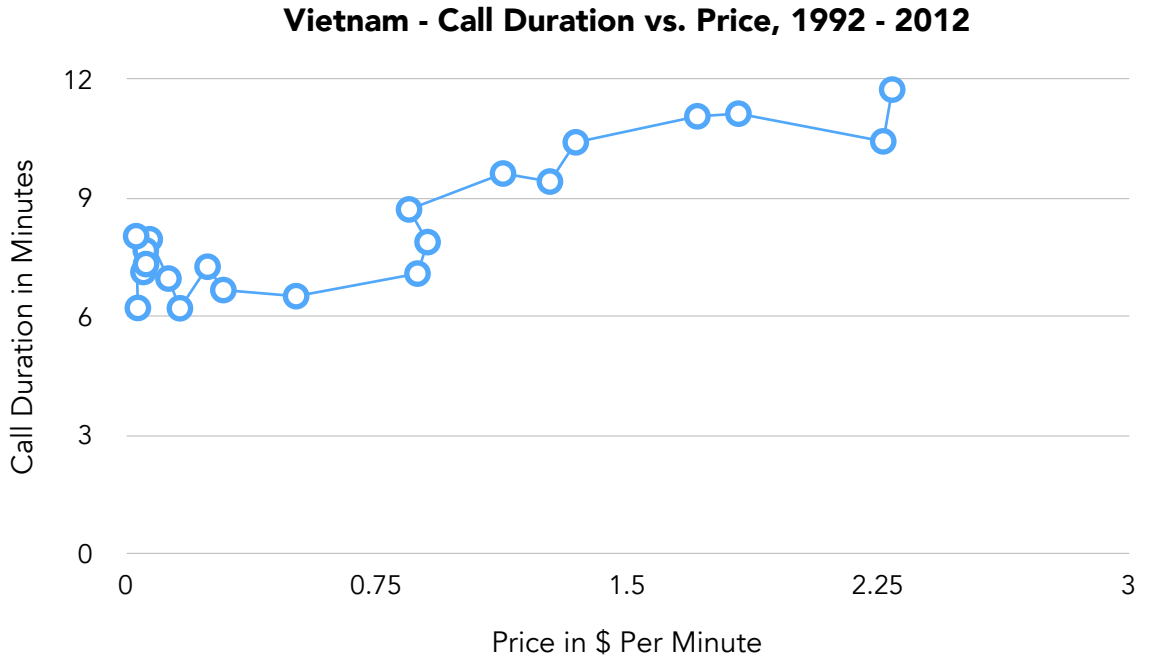
0.3
0.6
0.9
1.2
Price in $ Per Minute


Vietnam - Call Duration vs. Price, 1992 - 2012
Call Duration in Minutes
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6
3
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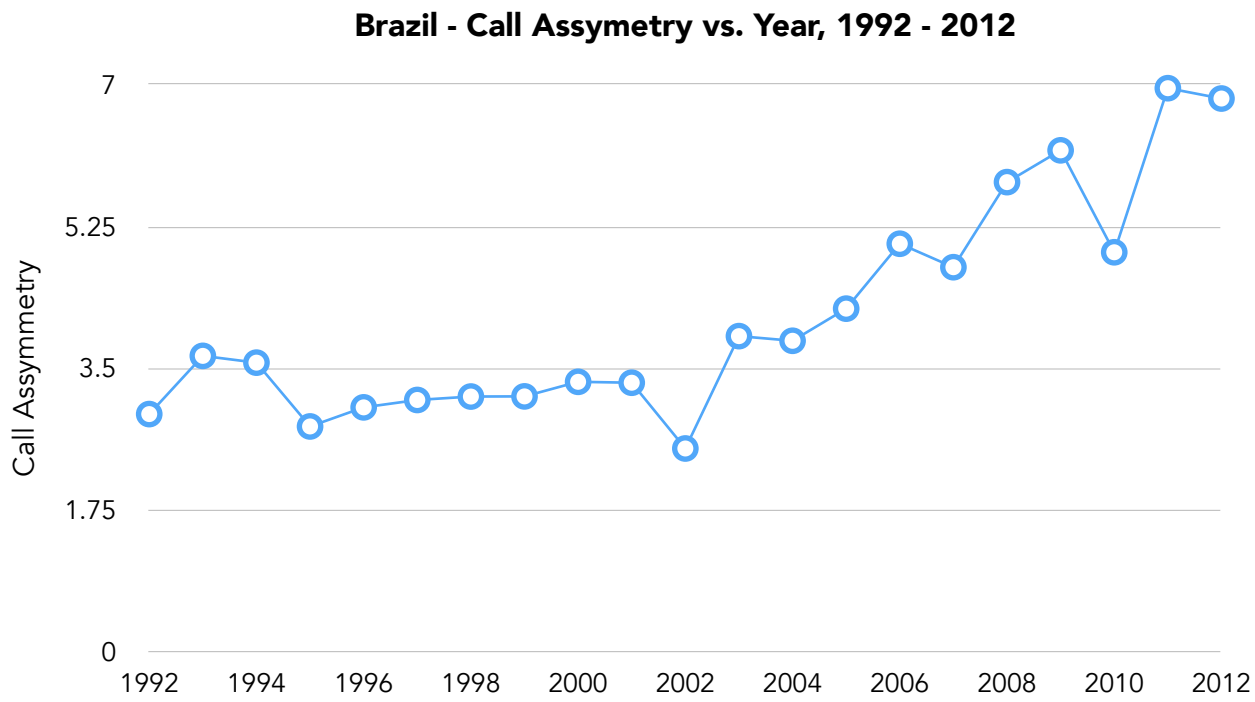
0
0.75
1.5
2.25
3
Price in $ Per Minute


Brazil - Call Assymetry vs. Year, 1992 - 2012
Call Assymmetry
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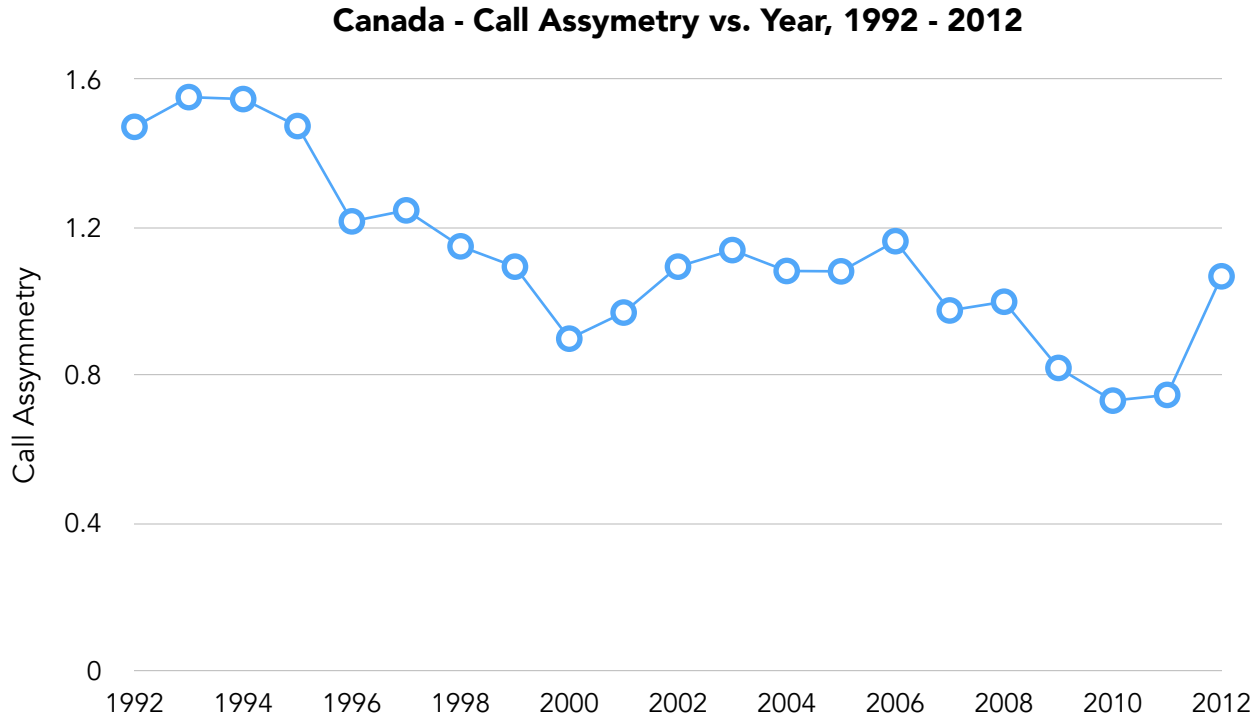
5.25
3.5
1.75
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012


Canada - Call Assymetry vs. Year, 1992 - 2012
Call Assymmetry
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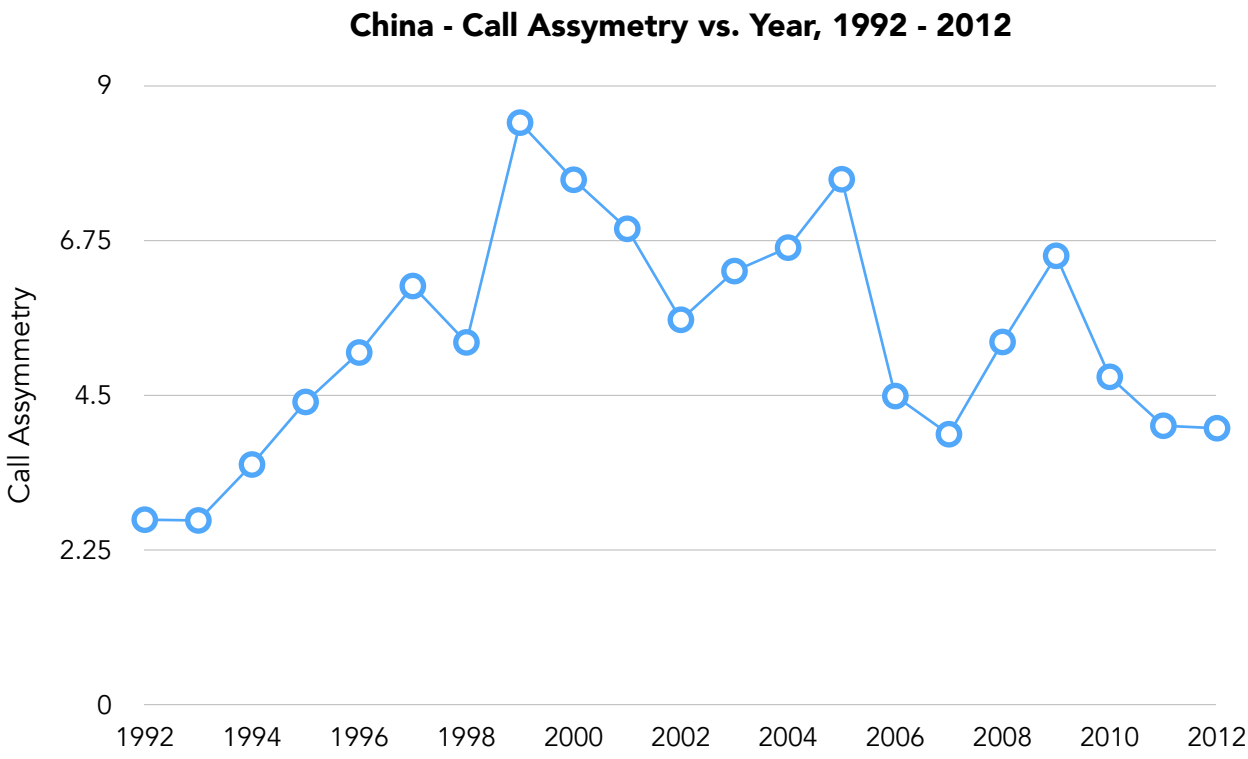
1.2
0.8
0.4
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012


China - Call Assymetry vs. Year, 1992 - 2012
Call Assymmetry
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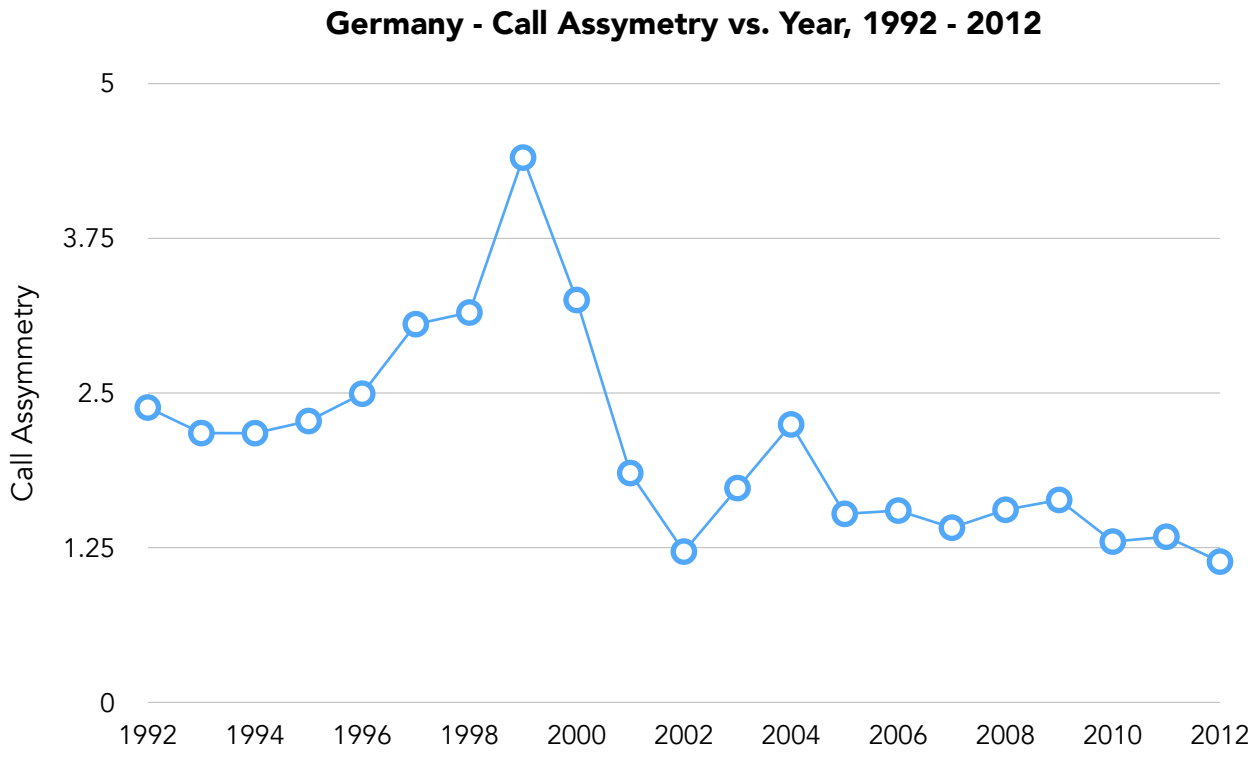
6.75
4.5
2.25
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012


Germany - Call Assymetry vs. Year, 1992 - 2012
Call Assymmetry
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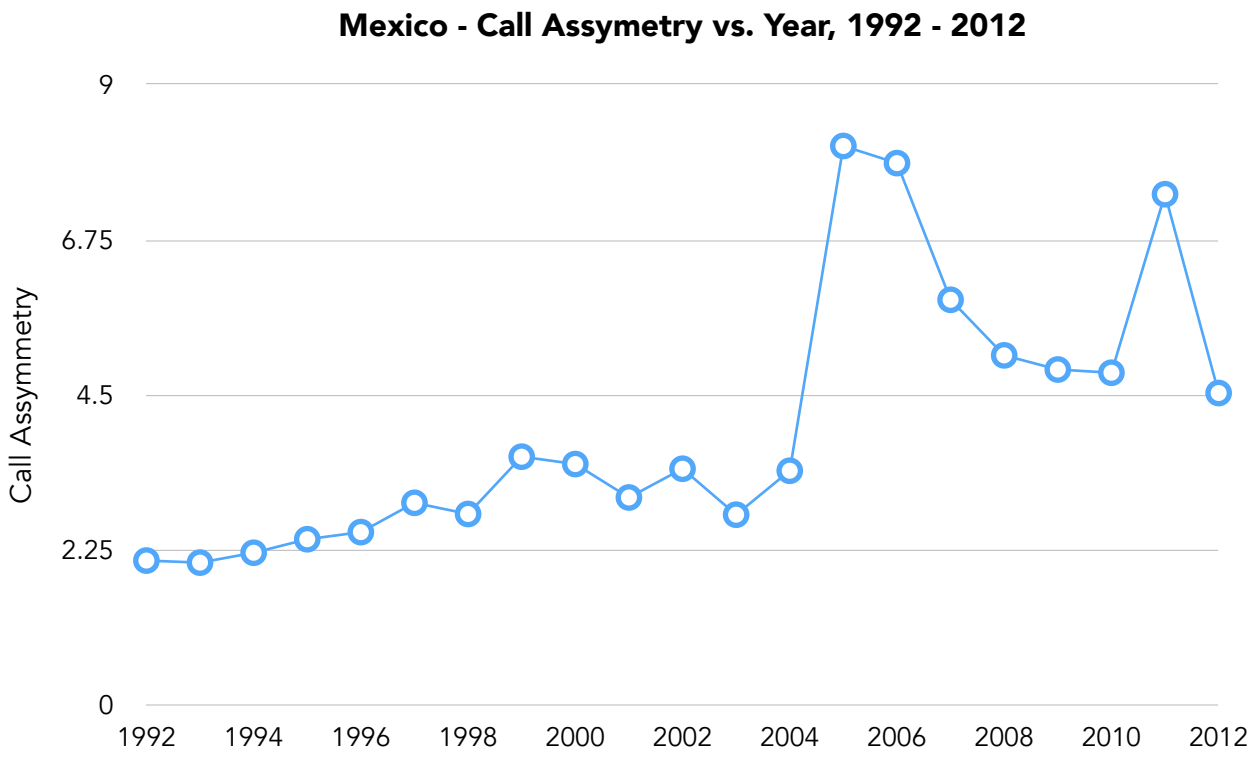
3.75
2.5
1.25
0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012


Mexico - Call Assymetry vs. Year, 1992 - 2012
Call Assymmetry
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6.75
4.5
2.25
0
1992
1994
1996
1998
2000
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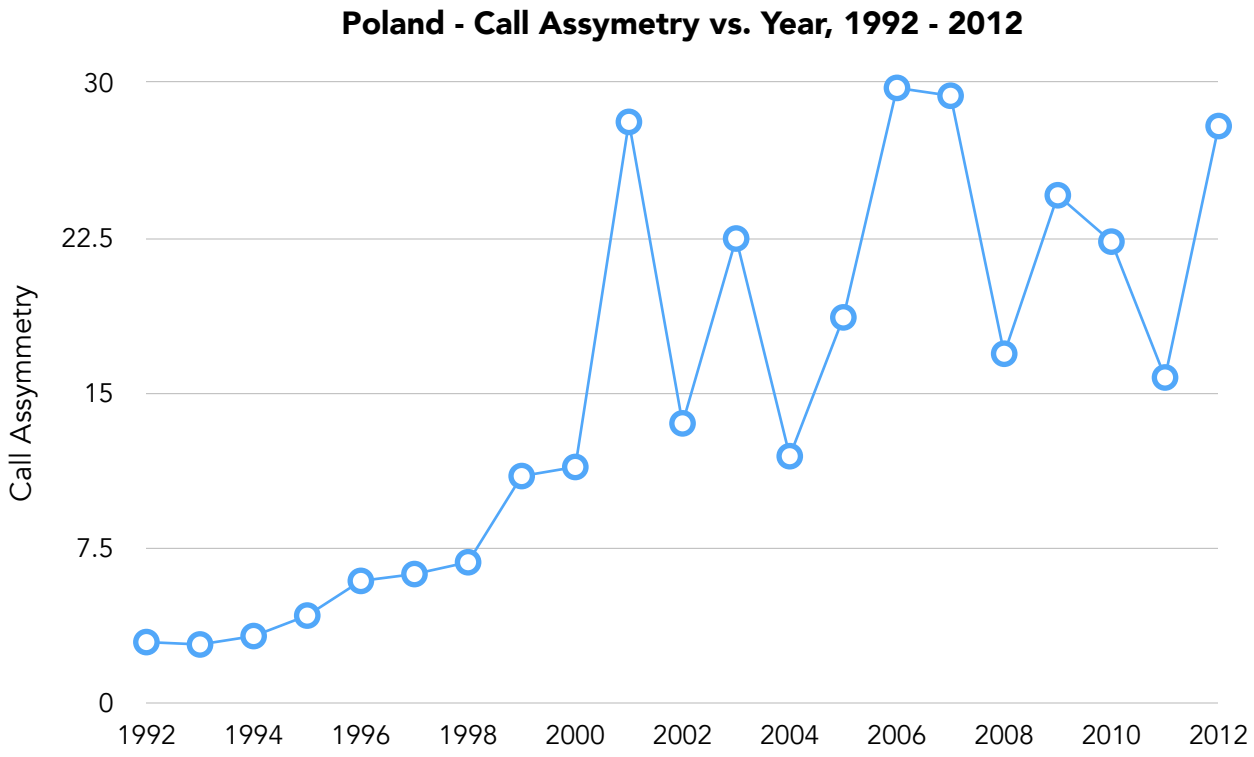
2004
2006
2008
2010
2012


Poland - Call Assymetry vs. Year, 1992 - 2012
Call Assymmetry
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15
7.5
0
1992
1994
1996
1998
2000
2002
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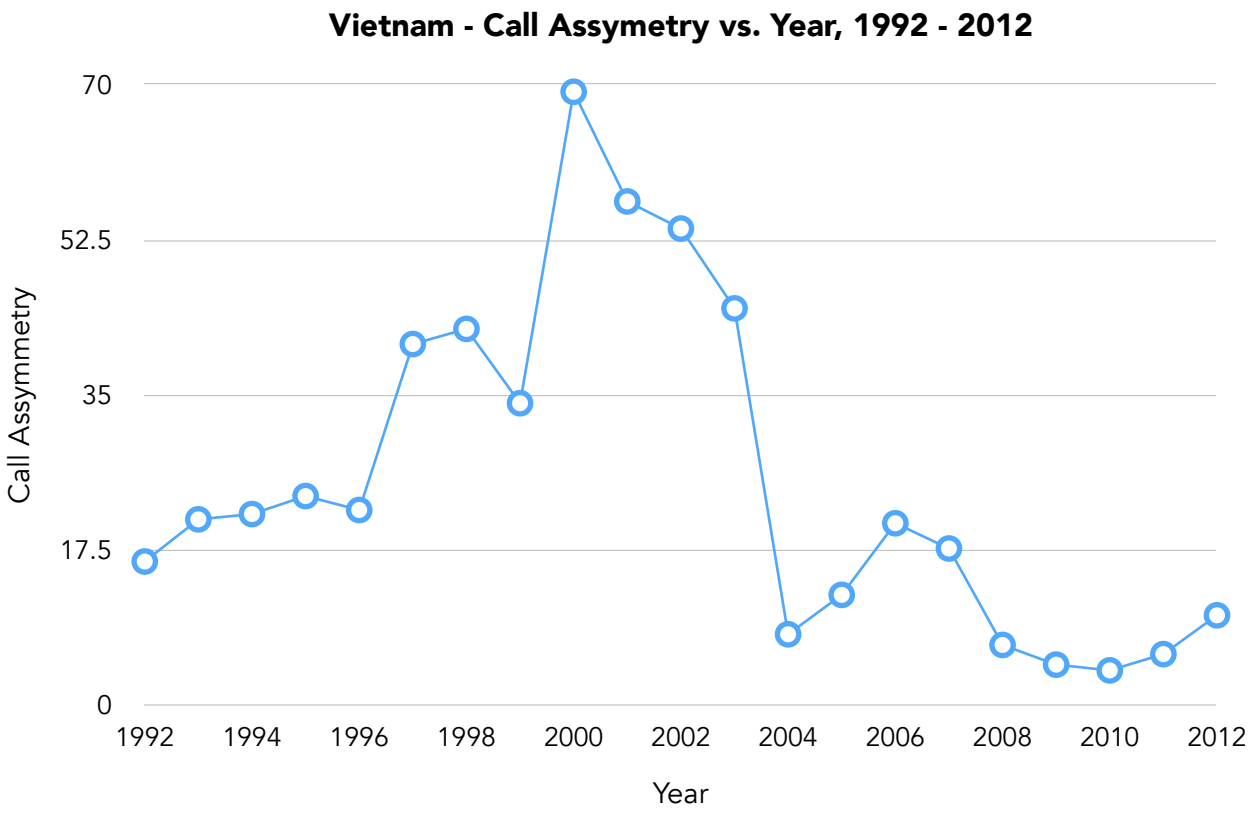
2006
2008
2010
2012


Vietnam - Call Assymetry vs. Year, 1992 - 2012
70
52.5
35
17.5
0
Call Assymmetry
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
Year