Spring 5-19-2016

Geospatial Modeling of Vietnamese FDI

Cuong Nguyen Tien
CUNY Hunter College

Geospatial Modeling of Vietnamese FDI

by

Cuong Nguyen Tien

Submitted in partial fulfillment
of the requirements for the degree of
Master of Arts in Economics
Hunter College of the City of New York

2016

Thesis Sponsor:

May 16, 2016	Jonathan Conning
Date	First Reader
May 16, 2016	Matthew J. Baker
Date	Second Reader

Abstract

This thesis sets a goal to analyze and project geographically disaggregated measures of FDI using aggregate data. We regress the country level FDI with aggregate, fine geospatial data on GDP, urban extent, and risk. By disaggregating the model, we will predict the FDI flow in every 1000 square kilometer area.

Introduction

Vietnam's economic transformation "doi moi" (=renovation) resulted from the depletion of the economy during the 1970s and early 1980s, when Vietnam was centrally planned economy. In December 1986 at the Sixth Party Congress, the leaders recognized the need of private ownership structure in Vietnam and approved the doi moi program.

Doi moi program consisted of a radical reform package with the aim to liberalize and open the economy to the world market. The package contained the following items: agricultural reforms, encouragement of the domestic private sector and foreign direct investment (FDI), removal of trade barriers, price liberalization, devaluation and unification of the exchange rate, increasing interest rates to positive levels in real terms, and reduction in subsidies to the State Owned Enterprise (SOE) sector.

The poverty rate fell from 58.1 percent in 1993 to 17.2 percent in 2012 according to the World Bank. GDP per capita increased from US$ 130 in 1990 to US$ 1740 in 2013. Total gross domestic product increased from US$ 15 billion to over US$ 171.4 billion in 2013. Annual inflation fell from 774 percent in 1986 to 67.5 per cent in 1990, 12.7 percent in 1995, and 8.8 percent in 2005 and around 6.6 percent in 2013.

FDI was expected to skyrocket after the reforms. FDI has been a very important factor for the economy. Todaro and Smith (2003) have proven that FDI has a positive significance to technology transfer, job creation, hence increase in economic growth, and reduce the poverty in the country. There have been many studies on FDI, however, there have been only few studies focusing on Vietnam's FDI and its impact to the local economy. Some of the determinants that have been subject of the studies of Changwatchai (2010) were inflation, GDP, education, infrastructure, taxes, and openness.

Our intention was to analyze and project geographically disaggregated measures of FDI using aggregate data. This should help us understand the scope of FDI in several regions of Vietnam

and our result should point out the main areas where the local governments need to take action in order to attract more FDI. The methods that we are using here have been developed by professor Matthew J. Baker in his work related to geospatial modeling.

In his work, professor Baker is using available higher level data to form a predictive model of health into more granulated area. The idea is to fill in missing data. For example, if we have only country-level data about health, we use his model to predict certain aspect of health on a smaller area of the country. Based on this idea, we decided to research FDI on the country level and project it in much smaller areas to see where the potential growth of FDI inflow is.

There have been many studies that used geospatial modeling to map income, poverty, but there have been few to map FDI. As Hentschel (2000) mentioned in their study on poverty, there is always a limitation due to scarcity of disaggregated data. Their poverty map provided a detailed spatial distribution of poverty within a country. It helps governmental organizations and NGOs to focus their help into certain provinces, areas, and households of the country. It creates efficiency in the allocation of resources and makes the process of reaching the poor more effective.

The methodology of disaggregating the model to fill missing data has been here for a while. Gary King (2000) used it in his study about the ecological inference. The last half decade has witnessed a great popularity of research in ecological inference. The field attempts to infer individual behavior from aggregate data. We are applying this method in our research in Vietnamese FDI.

The thesis contains four sections. The first one gives an overview of the FDI inflow of Vietnamese economy. The second section of the thesis is looking into the aggregate model that eventually helps us to predict FDI in smaller areas using disaggregated data. In the third section we are describing our final results that consequently lead us to the final projection and conclusion.

Overview

In late 1989, when the collapse of communism started in Eastern Europe, a multi-party system reforms were on a debate. The reformist leader, Tran Xuan Bach, after suggesting a plural political system was removed from the Politburo and several reformers who supported the idea were politically persecuted. The Vietnamese Communist Party (VCP) leadership could not accept any possibilities of losing superiority in the country, but on the other hand to gain support of the population they responded by the set of amendments: secret ballot voting, separated functions of party and state institutions, selection of leaders both within and outside the party, the party policy being subject to the law made by the National Assembly. The collapse of communism in Eastern Europe made the party more cautious about any liberal changes to the system and as Chinese leaders the Vietnamese also aimed to the transition model without any significant changes in the political system.

Since 2000, according to the World Bank, Vietnam has been ranked in top 20 countries with the highest growth. In 2003 it was 6.00% increasing to 8.50% in 2008 and in 2010 slowed down to 5.30% of growth.

Services and construction were undergoing rapid growth during 1995 to 2005. Almost 2.5 million new private entrepreneurs and household businesses were created in urban areas. The private sector became a major source of employment in the economy.

Concerning SOEs, the government reduced their subsidies and gave them greater autonomy. Inefficient enterprises with serious financial problems have been liquidated and the number of SOEs decreased by 50 percent according to Tran Van Tho (2004).

The trade and investments have been liberalized in an attempt to integrate the economy with the rest of the world. Trade agreements have been signed with about 60 countries and there have been trade relations with more than 170 countries. Since 1992 Vietnam agreed on a preferential trade with the European Union (EU). In 1995 it became a member of the

Association of South East Asian Nations (ASEAN) and in 1998 Vietnam joined the Asia Pacific Economic Co-operation (APEC). This positive economic integration culminated in the signing of agreements to join the World Trade Organization and the bilateral economic partnership with Japan in 2007.

Liberalization process brought a rapid growth in FDI to the country between 2000 and 2008. Since 2001 Vietnam managed to attract about another 50 countries to invest inside the country. FDI has become a major source of the Vietnamese economy. To serve the trade and investment well the banking sector was reformed. Two-tier system replaced the mono-banking system and the State Bank of Vietnam began to play a new role of the supervisor of the financial system.

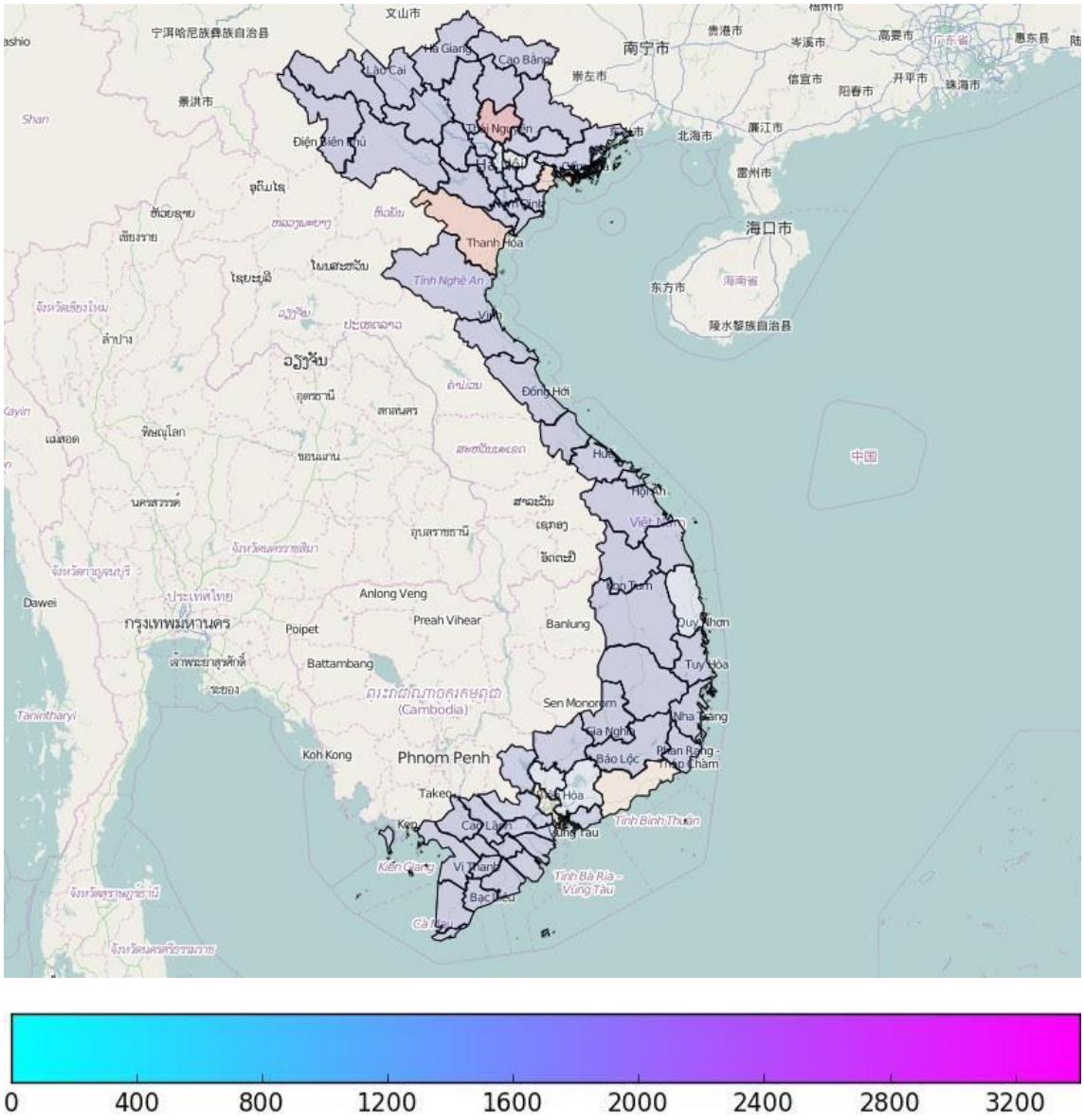
Methods

In our model we will use gridded data from satellite to form a predictive model for FDI flow in the particular region. The main idea is to get the prediction of FDI onto a global grid. The map will be able to show the FDI flow in 1000 square kilometer precision. One can use the map for specific regions with high potential investment flows.

First we are going to do is to find aggregate country-level data that we would like to investigate more in much more detailed area. In our case it is going to be FDI flow of the countries all over the world. Second would be to get granulated data about the risk, and urban extent in the region per 1000 square kilometer which is the finest we can get from freely available satellite data. Third, we need to aggregate the granulated data which basically means to sum all the 1000-square-kilometer tiles into a country shape to find the aggregate country-level data for them.

Afterwards the creation of a regression model will be necessary to fit the aggregated data into our FDI model. This way we can get the predictions of each country's FDI using our aggregated predictors. Next step would be to disaggregate the model and predict the FDI flow in more granulated details.

Figure 1: FDI projects in mil. $



In the Table 1 below we can observe that based on the number of FDI projects, the leading provinces are Ho Chi Minh City and Ha Noi City. However, as the Figure 1 shows, if we consider dollar amount of FDI flow, the provinces that are ahead include Thai Nguyen and Thanh Hoa, followed by Hai Phong City. Ho Chi Minh City and Ha Noi City are 6th and 9th, respectively. If we go further on and calculate the average dollar amount per each project in all provinces, Ha Noi City and Ho Chi Minh City will end up way further down with $4 million and $4.1 million per project. This is explained by the maturity of the region. Both region lead in the number of projects but the project size has shrunk and the pool consist of much smaller projects.

Table 1: Number of FDI projects by provinces

Province name	FDI projects
Ho Chi Minh City|Ho Chi Minh	**491**
Ha Noi City|Hanoi	**261**
Binh Duong	**125**
Bac Ninh	**122**
Dong Nai	**80**
Long An	**46**
Da Nang City|Da Nang	**37**
Hung Yen	**31**
Hai Phong City|Haiphong	**28**

Source: *General Statistics Office of Vietnam*

Table 2: Average dollar amount per each project in mil. $ by provinces

Province name	Average dollar amount per project (mil. $)
Thanh Hoa	**$ 731.1**
Binh Thuan	**$ 169.4**
Thai Nguyen	**$ 154.9**
Binh Dinh	**$ 128.8**
Hai Phong City|Haiphong	**$ 93.4**
Son La	**$ 49.2**
Kien Giang	**$ 38.2**
Hai Duong	**$ 34.1**
Tien Giang	**$ 27.2**

Source: *General Statistics Office of Vietnam*

Data

Data have been obtained from the website of the Socioeconomic Data and Application Center (SEDAC). Our FDI data are from the General Statistics Office of Vietnam and global FDI data were obtained from the World Bank.

To find out the significant determinants of FDI many studies and literature found GDP, urban extent, and risk to be significant. All of these factors affect FDI in some extent. Many studies have been conducted to study the determinants of FDI but very few of them use regression analysis or geospatial data. According to Wu (2013), among the possible significant independent variables are GDP, human capital, market size, export, import, inflation, infrastructure, and risk.

For our study we were able to gather GDP data, urban extent (urbext) and for risk we used global cyclone total economic loss (cyc) data that was obtained on SEDAC.

Table 3: Sources of data

Data	Source	Level	year
FDI	**World Bank**	**country-level**	**2014**
GDP	**SEDAC**	**15x15minute granulated-level**	**2014**
CYC	**SEDAC**	**15x15minute granulated-level**	**2014**
URBEXT	**SEDAC**	**15x15minute granulated-level**	**2014**

Model

Aggregated model:

$$FDI_{country-level} = \beta_0 + \beta_1 GDP_{country-level} + \beta_2 CYC_{country-level}$$

$$+\beta_3 URBEXT_{country-level} + \beta_4 LAT_{country-level} + \beta_5 LON_{country-level}$$

Several options and iterations of aggregated model have been tried and none of other models (such as with GDP squared or cross relationship URBEXT*CYC) seem to increase our R-squared. That is why we chose the above model as the most appropriate.

Table 4: Variables

FDI	Country-level Foreign Direct Investment
GDP	Country-level Gross Domestic Product
CYC	Country-level Cyclone Total Economic Loss
URBEXT	Country-level Urban Extent
LAT	Country-level Latitude
LON	Country-level Longitude

Projection model:

$$\boldsymbol{FDI_i = \beta_0 + \beta_1 GDP_i + \beta_2 CYC_i + \beta_3 URBEXT_i + +\beta_4 LAT_i + \beta_5 LON_i}$$

As we mentioned above we are going to use five independent variables for our model. In order for us to be able to use the granulated geodata in our regression, we need to convert them into country-level data. Variables urbext and cyc need to be sum up within a specific country. The best way is to create a dummy variable that flags a tile to a specific country. Then we will be able to sum the tiles up using these flags. The methods that we are using here have been developed by professor Baker in his work related to geospatial modeling.

We found the global FDI data in the database of the World Bank. Data have been collected annually since 1981. For our dataset we are going to use the year of 2014. It is going to be our dependent variable whereas data on GDP that we gathered from the World Bank database is going to be our independent variable together with variables urbext, cyc, whose data have been obtained through SEDAC.

After aggregating gridded data, we are going to join our datasets. For all our analyses we are using Python and its statistical packages for modeling such as **statsmodels**, **pandas**, and for geospatial modeling **geopandas**. For conversion of tiff files into geodataframe we are using professor Baker's package **tifftogdf**.

Results

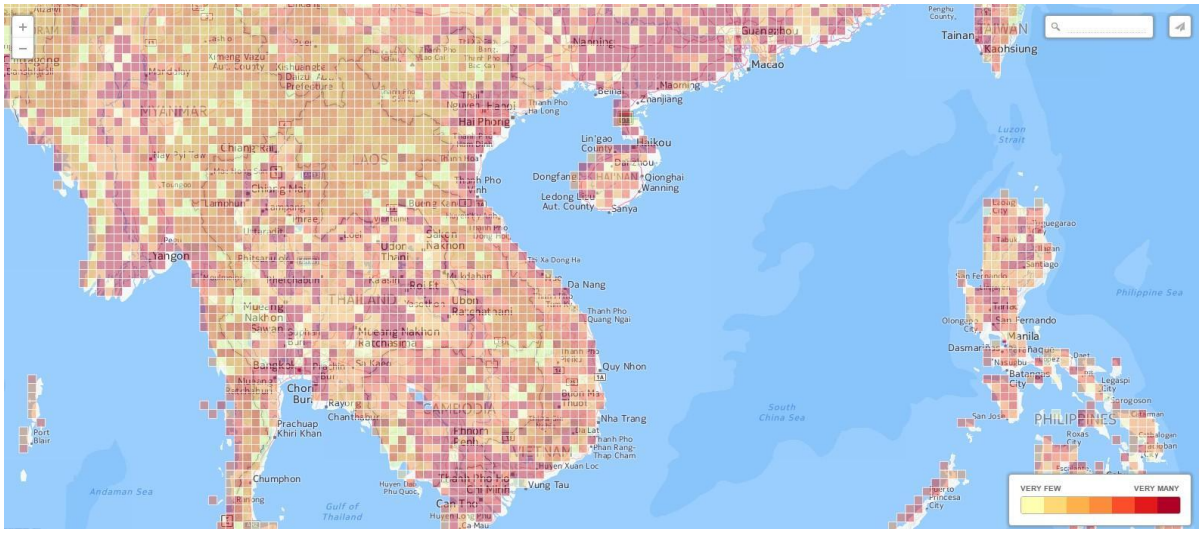
Table 5: Regression results

Variable	***Coefficient***	***P-Value***
GDP	0.0109	0.000*
Urban Extent	0.0000000001478	0.067
Cyclone Total Economic Loss	-0.000005286	0.866
Latitude	0.0000001928	0.828
Longitude	0.0000002191	0.531
Constant	-0.0000000001534	0.095

* statistically significant at the 5-percent level

After running regression on aggregated data we got coefficients of our predictors that we can use for our FDI model. The regression results are significant for GDP and urbext only but they are good enough for us to create a geospatial predictive model and apply the method that professor Baker used. We use our regression model to predict each tile in the whole world which represents FDI flow in the specifically granulated region on the map.

Figure 2: FDI flow



The results are telling us that Ha Noi and Ho Chi Minh and their agglomerates are the most attractive for foreign investors. Da Nang is definitely on the rise regarding the FDI flow. The issue in Da Nang is that it might be riskier due to higher cyclone occurrence than other growing cities such as Can Tho or Hai Phong. Ha Noi and Ho Chi Minh are definitely the leading cities though in the recent years the pace that the FDI to these two cities is flowing seems to be much slower than before. The stars of our analysis are Thai Nguyen, Thanh Hoa, and Binh Thuan that should definitely be under the radar of foreign investors because, according to our predictions, these provinces are going to be the next FDI hubs like Ha Noi and Ho Chi Minh City. We can see the shift since the liberalization process which brought a rapid growth in FDI to the country between 2000 and 2008. Since 2001 Vietnam managed to attract about another 50 countries to invest inside the country. More and more the less known provinces are booming. FDI has become a major source of the Vietnamese economy.

Conclusion

Goal of this study was to analyze and project geographically disaggregated measures of FDI using aggregate data and project it using Python and geospatial modeling into smaller much more granulated areas to find the regions with a great potential for growth. All of our regression coefficients came out with the signs as expected. FDI seems to increase with higher GDP and urban extent, both variables are statistically significant. The cyclone total economic loss seems to have negative effect on FDI; however it did not come out as significant. One of our limitations was lack of granulated data that we could use for our geospatial modeling. From the previous studies we can observe that inflation, infrastructure, and education play an important role in FDI flows. Another limitation has been the technology, the more granulated data we worked with, the slower the performance of our calculations and visualization. We hope that in our next study we will not have these limitations and the research could be conducted with more variables and more detailed data.

Our projections came very close to the data on provinces which were reflected in Figure 1 above using python and mapping. The data showed Ha Noi, Ho Chi Minh as the leaders in the number of FDI projects in the country. The projection not only confirmed this information but also showed specifically which regions are the next ones on the rise. According to our projection, Thai Nguyen, Thanh Hoa, Binh Thuan are three provinces that investors should pay a closer look when deciding where to put their money.

Vietnam has failed to manage problems that many East Asian countries had to deal with before. According to the World Bank, Vietnam scored lower than all East and Southeast Asian countries except Indonesia in government effectiveness, voice and accountability regulatory, and quality of law according to Kornai and Qian (2009).

Vietnam's ranking in the category of "governance effectiveness" declined between 1996 and 2010. But it does not mean that Vietnam did not concentrate on this area, it just means that other countries performed better and their improvement was much faster.

By replacing the bureaucratic apparatus or reducing the number of ministries may produce some effective gains, but absolutely more will be gained by limiting the power of the state and its functions. The state should focus on key areas only.

In recent years the donor community has poured large sums of money into existing administrative apparatus to help public administration reforms without success because the existing apparatus did not fundamentally change anything of what it does. The Vietnamese government's own reform has been a bigger success, especially the Enterprise Law that set up the essential basis of the market structure. Vietnam is now facing new challenges that need much more elaborate solutions.

"The country needs to reform education system, healthcare, resolve the infrastructure crisis, and meet the challenges of urbanization and environmental degradation, this will require better government, not just less government."

Le Dang Doanh (2002)

If Vietnam wants to achieve its ambitious development objectives, the economy must keep pace with other East and Southeast Asian countries continue to perform high rate of growth and FDI for the next several decades. This has been shown as a very difficult objective to achieve for many Asian dragons. And indeed most of the developing countries started to slow down their growth when they reached a certain level of wealth. And Vietnam, of course, will approach this level soon. Vietnamese politicians must therefore ask themselves: how can Vietnam sustain its phenomenal growth?

"It should be clear that the only way to achieve a sustained high rate of economic growth for several decades more is to identify the sectors with the most growth potential and provide them with the environment and inputs needed to thrive."

Rodrik (2007)

The Vietnamese economy is driven by private and the foreign invested sectors. These sectors are most likely to ensure the prolonged economic growth on which Vietnam's future depends. However, the government is not providing these sectors, especially the private sector, with the conditions that are needed to guarantee their success in the future.

Government industrial policy remains biased in favor of the sector that objective analysis reveals is the least competitive, generates the fewest jobs, and delivers the lowest growth rate. This is to place the economy against the necessity to sustain a high rate of growth for the next several decades, it is no different from a general who sends his weakest soldiers first to the war.

Appendix

OLS Regression Results

Dep. Variable:	FDI	R-squared:	0.640
Model:	OLS	Adj. R-squared:	0.629
Method:	Least Squares	F-statistic:	57.60
		Prob (F-statistic):	3.33e-34
		Log-Likelihood:	-4199.3
No. Observations:	168	AIC:	8411.
Df Residuals:	162	BIC:	8429.
Df Model:	5		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[95.0% Conf.	Int.]
Intercept	-1.534e+10	9.14e+09	-1.679	0.095	-3.34e+10	2.7e+09
GDP	0.0109	0.001	16.093	0.000	0.010	0.012
urbext	1.478e+10	8.03e+09	1.842	0.067	-1.07e+09	3.06e+10
cyc	-5.286e+06	3.12e+07	-0.169	0.866	-6.7e+07	5.64e+07
np.abs(LAT)	1.928e+07	8.84e+07	0.218	0.828	-1.55e+08	1.94e+08
np.abs(LON)	2.191e+07	3.49e+07	0.628	0.531	-4.7e+07	9.08e+07

Omnibus:	124.204	Durbin-Watson:	2.036
Prob(Omnibus):	0.000	Jarque-Bera (JB):	1634.877
Skew:	2.527	Prob(JB):	0.00
Kurtosis:	17.422	Cond. No.	1.91e+13

```
import math
import patsy
import pickle
import numpy as np
import pandas as pd
import os
import matplotlib.pyplot as plt
import statsmodels.formula.api as sm
import pylab
from geopandas import GeoDataFrame,GeoSeries

from statsmodels.regression.linear_model import OLSResults
FDIModel = OLSResults.load("FDIModel.pkl")
print(FDIModel.summary())

WorldGrid=pd.read_pickle('WorldGrid.pkl')
FDIDataSet=pd.read_pickle('FDIDataSet.pkl')
FDIDataSet.to_csv('regressiondata.txt')
FDIModel=sm.ols(formula='FDI ~ GDP + urbext + cyc +
np.abs(LAT)+np.abs(LON)',data=FDIDataSet).fit()
print(FDIModel.summary())
CountryDesignMatrix = patsy.dmatrix("GDP + urbext + cyc + np.abs(LAT)+np.abs(LON)",
data=FDIDataSet)
GriddedDesignMatrix = patsy.dmatrix("GDP + urbext + cyc + np.abs(LAT)+np.abs(LON)",
data=WorldGrid)

WorldGrid=WorldGrid.dropna()
WorldGrid['FDIPredict']=FDIModel.predict(GriddedDesignMatrix,transform=False)

WorldGrid['FDIPredict'].hist()


 WorldGridMat=GeoDataFrame(WorldGrid.copy(deep=True))
 WorldGridMat.set_index(['LAT','LON'],inplace=True)
 WorldGridMat=WorldGridMat.unstack()
 WorldGridMat.sort_index(axis=0,inplace=True)
 WorldGridMat.sort_index(axis=1,inplace=True)

 g=WorldGridMat['FDIPredict']

 plt.contour(g.columns.values,g.index.values,g)

 gridstep=20.0
 minLon=100
 maxLon=110
 minLat=5
 maxLat=30


 RangeLon=np.arange(minLon,maxLon+gridstep,gridstep)
 RangeLat=np.arange(minLat,maxLat+gridstep,gridstep)

 WorldGrid.columns

 for i in range(0,len(RangeLon)-1):
     for j in range(0,3):
         WorldGridTile=WorldGrid[(WorldGrid['LAT']>=RangeLat[j]) &
(WorldGrid['LAT']<RangeLat[j+1]) & (WorldGrid['LON']>=RangeLon[i]) &
(WorldGrid['LON']<RangeLon[i+1])]
         if len(WorldGridTile)>0:
             WorldGridTile.plot(column='FDIPredict',colormap='hot')
         print("Tile",i,j,"completed.")
 mplleaflet.show(path='CompleteTiles.html')
```

Bibliography

A Data Center in NASA's Earth Observing System Data and Information System. SEDAC. http://sedac.ciesin.columbia.edu/data/sets/browse

Anh, N. N., and Thang, N., 2007. "Foreign direct investment in Vietnam: An overview and analysis the determinants of spatial distribution across provinces".

Acemoglu, D., Johnson, S., Robinson, J., Yared, P., 2008. Income and democracy. American Economic Review 98, 808-842.

Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.3, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, August 2009.

Asiedu, E. 2002. On the determinants of foreign direct investment to developing countries: is Africa different. Econometric

Baker, Matthew J. Projecting health data the world over. https://github.com/mbaker21231/PhdTwo

Basu, P., Ckakraborty, C., and Reagle, D., 2003. Liberalization, FDI, and growth in developing countries: a panel co-integration approach. Economic Inquiry

Cernat, L., and Vranceanu, R., 2002. Globalization and development: new evidence from central and eastern Europe. Comparative Economic Studies

Chakrabarti, A., 2001. The determinants of foreign direct investment: sensitivity analyses of cross-country regressions. Kyklos, 54, 89-113.

Changwatchai, 2010. The Determinants of FDI inflows by industry to ASEAN (Indonesia, Malaysia, Philippines, Thailand, and Vietnam). Department of Economics, the University of Utah, August, 2010.

Chow, Gregory C., 2010: China's Economic Transformation, Princeton University Press, Princeton

De Haan, Jakob, 2007: "Political Institutions and Economic Growth Reconsidered" Public Choice 131 pp: 281-292.

General Statistics Office of Vietnam. https://www.gso.gov.vn

Grosjean P., Senik C., 2010: Democracy, Market Liberalization and Political Preferences, The Review of Economics and Statistics, MIT Press

Hentschel, J., Lanjouw, J. O., Lanjouw, P., & Poggi, J., 2000. Combining census and survey data to trace the spatial dimensions of poverty: A case study of Ecuador. The World Bank Economic Review, 14(1), 147-165.

King, G., Tanner, M. A., & Rosen, O. (Eds.)., 2004. Ecological inference: New methodological strategies. Cambridge University Press.

Kornai, J., 1992: The Socialist System: The Political Economy of Communism (Oxford: Oxford University Press)

Kornai, J. and Qian, Y., 2009: Market and Socialism: In the light of the experiences of China and Vietnam (London: International Economic Association)

Le Dang Doanh, 2002: Foreign Direct Investment in Vietnam: Results, Achievements, Challenges and Prospect, paper presented at IMF Conference on Foreign Direct Investment, Hanoi.

Minier, Jenny A., 1998: "Democracy and Growth: Alternative Approaches" Journal of Economic Growth; 3(3), pp: 241-66

Nolan, Peter, 2004: China at the Crossroads, Cambridge: Polity Press

North, D., 2005: Understanding the Process of Economic Change. Princeton University Press, Princeton

North, Douglass C. 1981. Structure and Change in Economic History, New York: W.W. Norton & Co.

North, Douglass C., and Robert P. Thomas. 1973. The Rise of the Western World: A New Economic History. Cambridge: Cambridge University Press.

North, D.,1990: Institutions, Institutional Changes and Economic Performance Cambridge University Press

Rodrik, D., 2007: One economics, Many recipes: Globalization, Institutions, and Economic Growth (Princeton University Press)

Persson, Torsten and Guido Tabellini, 2007: "The Growth Effect of Democracy: Is It Heterogeneous and How Can It Be Estimated?" NBER Working Paper 13150.

Rodrik, Dani and Romain Wacziarg, 2005: "Do Democratic Transitions Produce Bad Economic Outcomes?" American Economic Review 95:2 pp: 50 -55.

Rodrik, D., 2007: One economics, Many recipes: Globalization, Institutions, and Economic Growth (Princeton University Press)

Schiffbauer M., Shen L., 2010: Democracy vs. dictatorship, Economics of Transition, Wiley Online Library

Todaro, M. P., and Smith, S. C., 2003. Economic Development. Pearson Education Limited.

Tran Van Tho, 2004: Foreign Direct Investment and Development of Supporting Industries in Vietnam, Obirin Daigaku Sangyokenkuyui-nenpo (Annual Bulletin of the Institute for Industrial Research of Obirin University)

World Bank. World Bank Database. http://data.worldbank.org/country/vietnam

Xuan and Xing (2008). Foreign direct investment and exports. Economics of Transition

Zhao, H. (2003). Country Factor Differentials as Determinants of FDI flow to China. International Business Review