ERIA-DP-2013-35

ERIA Discussion Paper Series

Estimating the Effects of West Sumatra Public Asset Insurance Program on Short-Term Recovery after the September 2009 Earthquake

Paul A. RASCHKY*

Monash University, Australia

December 2013

Abstract: *This paper analyses the effect of the West Sumatra public asset insurance program on short-term economic recovery after the September 2009 West Sumatra Earthquake. We use satellite data on yearly differences in nighttime-light intensity as a proxy for economic activity, to investigate the effect of the earthquake damage on overall luminosity in 2009 and the progress in recovery in the year 2010. Our identification strategy applies a regression discontinuity (RD) approach that exploits the discontinuity in insurance coverage at the provincial border. We find a small, statistically significant and positive effect of the public insurance scheme on the short-term recovery in West Sumatra.*

Keywords: Natural Disaster Exposure, Economic Activity, Spatial Analysis, Natural Disaster Insurance.

JEL Classification: G22, Q54, R11

* Monash University, Department of Economics, Caulfield East, VIC 3145. paul.raschky@monash.edu. The author would like to thank Brent Carney for valuable research assistance and workshop participants at the ERIA project workshops in Jakarta and Singapore in for valuable feedback and discussion.

1. Introduction

Over the past two decades, ASEAN countries have experienced a number of large-scale natural disasters, such as floods, earthquakes and cyclones. According to a recent study by Global Facility for Disaster Reduction and Recovery (GFDRR 2012), the region's annual expected losses are well in excess of 0.2 % of regional GDP. Among the poorer ASEAN member countries such as Cambodia, Lao PDR, Myanmar, the Philippines or Vietnam, this figure could even be as high as 0.7% of GDP.

Already a large theoretical and empirical economic literature on the impacts of natural disasters on economic growth exists (Cavallo & Noy 2009). The cross-country analysis by Tavares (2004) shows that natural disasters have a small, but negative effect on economic growth. Loayza, *et al*. (2012) find that developing countries economic growth is more sensitive to natural disasters. While they find that some natural disasters have a negative impact on total economic growth, some disaster types can actually have a small positive effect on growth in some sectors. Cavallo, *et al*. (2013) use a synthetic control method approach and find that only very large disasters have an impact on economic growth, both in the short and long run. Some studies follow the idea of a vintage capital model (e.g. Hallegatte and Dumas 2009) and argue that some types of natural disasters can actually have a positive effect on economic growth because the initial destruction of physical capital may also lead to an update of the existing capital stock and thereby increasing overall productivity (e.g. Skidmore and Toya 2002, Crespo, *et al*. 2008, Leiter, *et al*. 2009). However, in order to update the destroyed physical assets, the economic agents require some form of liquid capital in the aftermath of a disaster.

Therefore, it is important to design policies that help to reduce the countries' exposure to disaster, mitigate the direct impact, and cope with the financial losses in the aftermath (e.g. Michel-Kerjan and Kunreuther, 2011). This paper is concerned with the last point, the financial risk-transfer mechanisms against natural disaster losses.

In the majority of cases, the humanitarian needs in the aftermath of the disaster are met by the respective governments. However, most countries struggle to obtain sufficient financial funds to finance post-disaster recovery in a timely manner (GFDRR 2012). In general, most ASEAN countries (notable exceptions are Malaysia and Singapore) follow a reactive rather than a pro-active financial risk-transfer strategy. The financial cost for the post-disaster recovery is largely covered either by post-disaster budget re-allocations or some form of tax-funded catastrophe fund. While necessary to ensure financial recovery, these post-disaster financing strategies have a number of drawbacks (Raschky and Weck-Hannemann, 2007). First, the collection of 'premiums' for the catastrophe funds is not based on the risk of a disaster loss of the underlying assets. In addition, catastrophe funds are often subject to the 'grabbing hand of the leviathan'. This means that in years without major disaster losses, politicians have an incentive to use some of the money allocated for the catastrophe fund in other budgetary areas. All of this can result in the lack of funds available in the case of a large-scale disaster. Second, both forms of governmental disaster assistance are prone to political discretion and corruption (e.g. Garrett and Sobel, 2007, Besley and Burgess 2002, Mustafa, 2003) and therefore do not necessarily help those in need or assure that relief is allocated in the most efficient way. Third, the expectations of governmental relief can crowd-out private demand for disaster insurance (e.g. Coate, 1995, Raschky and Weck-Hannemann 2007, Raschky, *et al*. 2013).

A more pro-active financial risk-transfer strategy in form of insurance that is funded by risk-based premiums could clearly improve recovery process and strengthen ASEAN countries resilience against natural disasters. In contrast to governmental relief, natural disaster insurance allows homeowners, entrepreneurs as well as local governments to make better informed, long-term decisions because their future expenditure (premiums) and income (claims) associated with financial risk-transfer is less subject to discretionary decisions. In addition, private insurance can improve the victims liquidity situation after a disaster in a more adequate and timely manner than governmental risk-transfer. Depending on the contract design, insurance companies are normally faster in assessing the damages and releasing reimbursements to the victims. Even if the process is delayed, the victims have an insurance policy at hand that shows the insurers contractual compensation obligation. This allows victims to borrow money in the short-run from banks to ensure a fast recovery. In comparison, governmental relief is uncertain and banks might be reluctant to lend money based on a politician's initial promise about the average relief size.

Although, it is intuitively convincing that areas with a higher penetration of private disaster insurance, should experience a faster recovery in the aftermath of a disaster as compared to areas with lower insurance penetration, an empirical study for the ASEAN region is missing.

Therefore, the purpose of this paper is to provide an empirical analysis of the effect of financial risk-transfer on short-term recovery. The major complication of such an empirical study for the ASEAN region is the lack of data in general and the lack of variability within the data in particular. Among ASEAN member countries, the penetration of financial risk-transfer mechanisms is very low and in most cases is organized in the form of ad-hoc relief from the respective federal governments. If some form of ex-ante risk-transfer mechanism exists, the penetration is very low and it is hard to compare risk-transfer system across ASEAN countries because they widely differ in their general design, the amount of coverage and other factors. In addition, the existence and extent of ex-ante insurance schemes is likely to be correlated with other, unobserved variables that pose a threat to the statistical identification of the true effect of the ex-ante risk-transfer mechanism on short-term recovery.

This paper uses variation in the geographical coverage of a provincial public asset insurance program in Indonesia to identify the effect of ex-ante insurance on short-term recovery after the September 2009 earthquake on Sumatra. Specifically, it analyses the effect of the public asset insurance program in West-Sumatra on short term recovery after the September 2009 earthquake using a regression discontinuity (RD) approach. To measure the short-term variation in economic activity, we apply satellite data on nighttime light activity that is available at a resolution of approx. $0.8km^2$ on a yearly basis. We first compare the changes in nighttime light intensity between 2008 and 2009 to analyse the impact of the earthquake on regional economic activity. We then compare the level nighttime light intensity in the year

2010 between pixels located in areas covered by the public asset insurance program with pixels located in other affected areas in Sumatra. Although the public asset insurance program only covers a small number of public buildings, we find a significantly positive effect of the insurance program on short term recovery in West-Sumatra.

This paper is organized as follows: Section 2 will provide background information about the September 2009 earthquake in Sumatra and the public asset insurance program in West-Sumatra. Section 3 introduces the data. Section 4 describes the econometric methodology. Section 5 discusses the results and section 6 concludes.

2. Background: The September 2009 Earthquake and the Public Asset Insurance Program in West-Sumatra

The September 2009 West-Sumatra earthquake

Situated atop one of the earth's most seismically active regions, Indonesia is no stranger to natural disasters. The archipelago parallels the boundary between the Eurasian plate and the subducting Indian-Australia plate, where tectonic stresses are frequently released as violent seismic activity. [1]

The West coast of the island of Sumatra has proven to be particularly susceptible to seismic shocks, with many (how many?) earthquakes of magnitude x or greater in the past 10 years.

One of the largest recent examples of the vulnerability of this region occurred as an earthquake of magnitude 7.6 on 30th September 2009. At 5:16pm local time the earthquake struck at a depth of 71km, 60km off the coast of Padang, causing damage in thirteen of the nineteen districts of the province of West Sumatra. The cities of Padang and Pariaman, and the district of Padang Pariaman experienced the majority of the damages. Tsunami warnings were triggered, however only a small local Tsunami (27cm in wave height) was recorded. A series of aftershocks rocked the wider region, the largest and most damaging being of magnitude 6.2 occurring in Jambi province, 215km southeast of Padang. [2]

The earthquake took a large human toll, with over 1,100 people killed and 2,900 injured, 1,200 seriously. Damage was also extensive, with total damages and losses estimated at RP 21.6 trillion, or approximately US $2.3 billion at 2009 exchange rates. (Perhaps insert damage map, similar to Map 3.4 of BNPB report). Over 88% of the total damages and losses were of a private nature, which mainly reflects the large losses sustained in the housing sector. The health and education sectors, services provided in a large part by the private sector, also suffered heavy losses in the order of RP 618 billion (US $66 million) and RP 744 billion (US $79 million), respectively. Owing to Padang's status as a major trading hub, the productive sector was also significantly affected, with damages and losses totalling in excess of RP 2 trillion (US $212 million).

Sectoral Impacts

There are five levels of Government in Indonesia: national, provincial, district, sub-district and nagari, or village, levels. A process of de-centralisation has seen a significant power shift away from the federal government towards the provincial and local-government levels. Many services such as healthcare, education, and infrastructure are under the remit of provincial and district governments. The nagari levels are responsible for registration of land and people, and play an important role in the implementation of government programs.

The earthquake inflicted heavy losses on the government sector, with total damage and losses estimated at RP 600 billion (US $64 million). Owing to the West Sumatran government and public administration facilities being located in Padang, the provincial government bore the brunt of this cost, with RP 264 billion (US $28 million) of damage, as shown in Table 1 below. Fortunately, since 2008 the province had insured a portion of its public assets against earthquakes.

Table 1. Damages and Losses in the Government sector (RP billion)

Government Sector	Damage	Losses	Total
Central government	124.8	1.8	126.6
Provincial government	264.3	3.3	267.6
Local government	159.3	7.7	166.5
Sub-district and nagari	33.5	1.8	35.3
Boarding houses (armed forces and police)	28.8	0.2	29.0
Total	**610.8**	**14.8**	**625.6**

Source: BNPB (2009).

While damage to government and public administration assets affected the provision of public services in the short term, at the provincial and district level these disruptions were temporary. At the nagari level, however, temporary office space and facilities were significantly more difficult to source and public services were slower to be restored.

Housing infrastructure in the region suffered the worst of the destruction, with damages and losses estimated at over RP 15.95 trillion (US $1.7 billion). This sector was particularly vulnerable to disasters due to poor designs and the inadequate quality of building materials such as concrete, masonry, and reinforcement. Buildings with a "soft-story" – a weak floor arising from architectural design features such as wide entrances and undercover parking – were particularly badly affected.

The earthquake impacted all the major areas of the productive economy in some capacity. Agriculture is the most important sector in the West Sumatran economy, employing nearly half of the province's workforce. While the disaster affected agriculturally-based livelihoods in the short term, the damages and losses were limited to around RP 280 billion (US $30 million), representing approximately 2% of the sector's GRDP (Gross Regional Domestic Product). However, the same cannot be said for trade and industry, the second and third biggest employers in the province. The cities hardest hit, Padang and Pariaman, are also the major trade and industry hubs for the region. While large industry escaped relatively unscathed, many small and medium enterprises (SME's) suffered significant damages. Total damages and losses to these businesses amounted to approximately RP 1.3 trillion (US $ 138 billion). To compound these losses, catastrophe-insurance uptake is concentrated to large industry, while many SME's are uninsured. Finally, damage to tourism infrastructure was moderate, around RP 71 billion (US $7.6 million), but the longer-lasting impact from lost tourist revenue was much more substantial and is estimated at RP 376 billion (US $40 million).

The ports, airports, and railways of the province escaped the earthquake relatively unscathed; however there was significant damage to the road network due to both shaking and landslides. Total damage and losses to roads and bridges is estimated at around RP 300 billion (US $32 million).

In any natural disaster the Indonesian government shoulders the lion's-share of reconstruction funding and the West-Sumatran earthquake was no different: A BNPB survey found that 68% of respondents expected government assistance in repairing/rebuilding damaged housing. As of January 2010 the central government had allotted a total of RP 6.47 trillion (US $688 million) to recovery projects, sourced from state and regional budgets, foreign aid, and NGO's.[3] Among the major international donors to the recovery effort were Australia (US $15 million)[4], the United States (US $12.1 million)[5], the European Union (US $4.3 million)[6], and the International Federation of Red Cross and Red Crescent Societies (US $12.9 million)[7].

Private catastrophe insurance uptake is low in Indonesia, where estimates for non-life insurance penetration range from 0.4 – 0.6% of GDP[8]. Despite the low overall uptake, total non-life insurance penetration in the affected areas was relatively high, with the BNPB estimating exposure at RP 720 billion (US $77 million). Munich-re estimated total insured losses to be greater than $US 100 million, which would make the West Sumatra earthquake the largest disaster payout in Indonesia for many years.[9] The provincial government of West Sumatra was the only level of government to have insured its assets against earthquake, tsunami and fire. As a result, in May 2010 the provincial government received a payout for the earthquake of US$2 million, one-hundred times the annual premium. Unfortunately, while the Padang municipal government was in the process of insuring some of its assets when the earthquake struck, the policy was yet to take effect.

The West-Sumatra province public asset insurance program

West-Sumatra Province is one of only a handful of provincial governments to have taken out catastrophe insurance. In 2007, the West Sumatra provincial government insured local assets against fire risk with PT Asuransi Bangum Askrida, an Indonesian insurance company. Following a series of large earthquakes in September 2007, coverage was extended in 2008 to include earthquakes and tsunamis. In 2010, the policy covered 42 local government buildings, four hospitals, and 73 local government official and guest houses[10] premiums are calculated using Maipark's earthquake insurance tariff and are levied at 1.25% of the total sum insured[11] or approximately US $20,000, and are appropriated annually in the local provincial budget[12]. In the aftermath of the 2009 West Sumatran earthquake, the provincial government received a settlement of RP 20 billion (US $2.2 million) in May 2010, seven months after the disaster.

3. Data

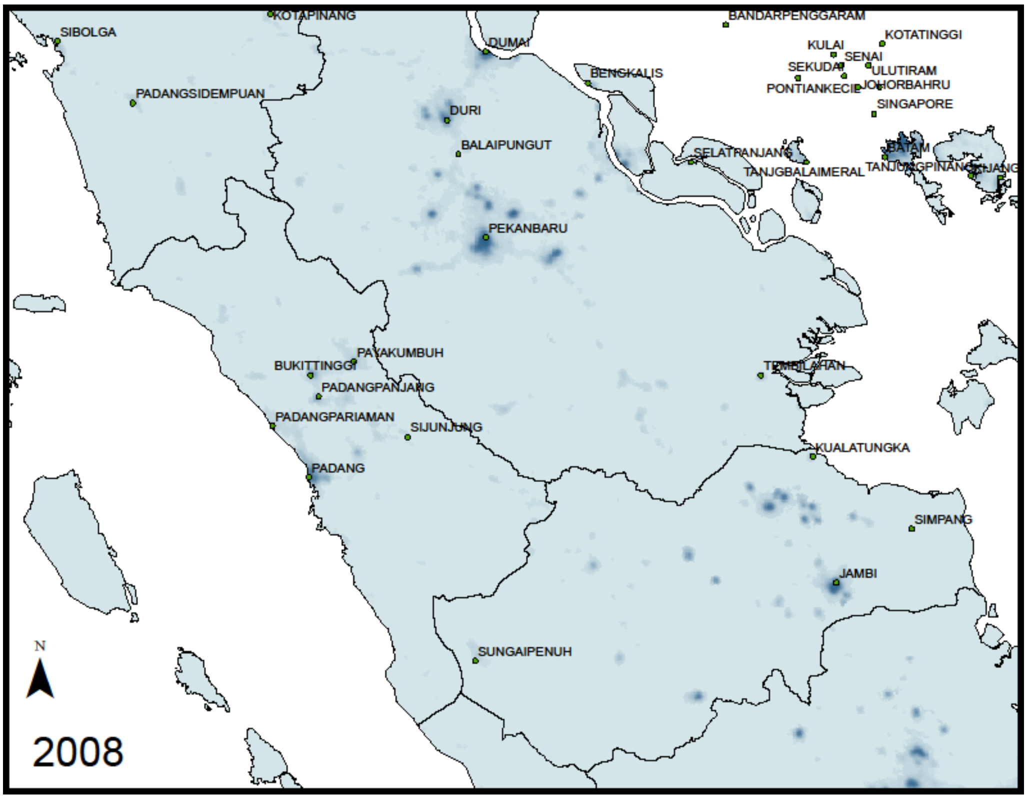
The nature of this study requires an empirical proxy for economic activity at a very disaggregated level. Using subnational GDP data at the province level is simply not disaggregated enough for this type of analysis because it would only result in a sample size of 5. Household level income data is very often not exactly geocoded (to ensure confidentiality) and again only limited to a small number of sample villages within each province. We therefore build on the recent economic literature that uses satellite images of nighttime light emissions as empirical proxy for economic activity (e.g. Henderson, *et al*. 2012, Elvidge, *et al*. 1997; Sutton and Costanza, 2002; Sutton, *et al*. 2007; Elvidge, *et al*. 2009; and Gosh, *et al*. 2009 as well as Hodler and Raschky, 2013, and Michalopoulos and Papaioannou, 2013).

Nighttime Light intensity is constantly recorded by US Air Force Weather Satellites, and annualized nighttime light data is provided by the National Oceanic and Atmospheric Administration (NOAA, 2012). The major advantage compared to other proxies of wealth and economic activity is that the data is available for any subnational region in any country at a very fine spatial resolution. In addition, it is collected in exactly the same way by one organization. As such, it provides proxy values for the concentration of physical assets and economic activity that is comparable across the ASEAN member countries. Weather satellites from the US Air Force circle the earth 14 times per day and measure luminosity worldwide between 65 degrees North and 65 degrees South every night sometime between 8.30 and 10.00pm. The final data contains only readings from the dark half of the lunar cycle in seasons when the sun sets early is used. Readings affected by northern or southern lights, forest fires and cloud cover are removed in order to collect only man-made light. The original nighttime light readings are then recalibrated to account for variations in sensor settings over time. This recalibrated data is delivered as a raster file with pixels that have values on a scale from 0 to 63, with higher values implying higher light intensity. This data is available for the time period from 1992 to 2011 and the average pixel size is about 0.8 km^2.

Henderson et al. (2012) find a strong correlation between changes in nighttime light and GDP at national level. Nighttime light is a good proxy for the concentration of wealth and infrastructure as a large fraction of these physical assets is lit during between 8.30 and 10.00pm. In addition, most forms of economic activity (consumption and production) in the evening require light.

Figure 1 presents a map of the affected provinces on Sumatra with nighttime light emissions for 2008. The main affected provinces were Bengkulu, Jambi, Riau, Sumatera Barat (West Sumatra) and Sumatera Utara. The darker areas around Padang, Pekanbaru, and Jambi nicely illustrate the higher concentration of nighttime light emissions in these regional urban centers. The epicenter of the quake was just off the coast of Padang.

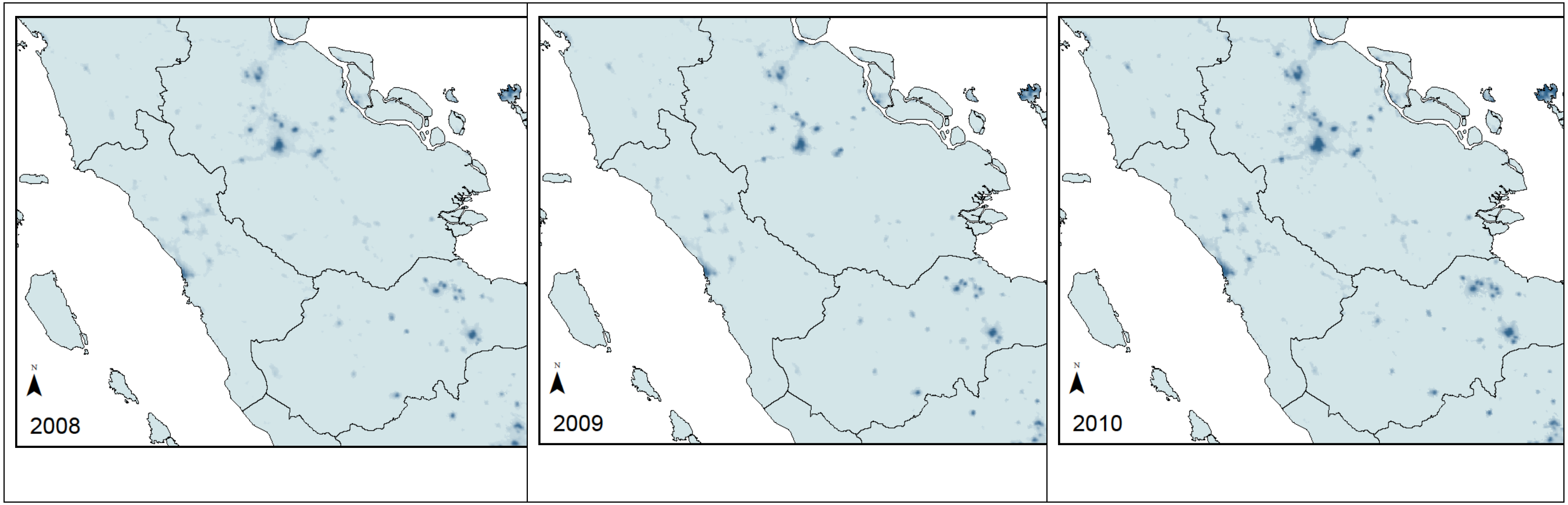
Figure 1: Nighttime Light Emissions in Affected Provinces in Sumatra, 2008 (darker pixels indicate more intense nighttime luminosity).



Source: Author, original data NOAA (2012).

Figure 2 illustrates the change in nighttime light intensity from 2008 to 2010. 2008 was the year prior to the earthquake. In September 2009, the earthquake hit Sumatra and a reduction of light time intensity is visible in particular around the urban centers. 2010 then reflects part of the economic recovery in the different provinces.

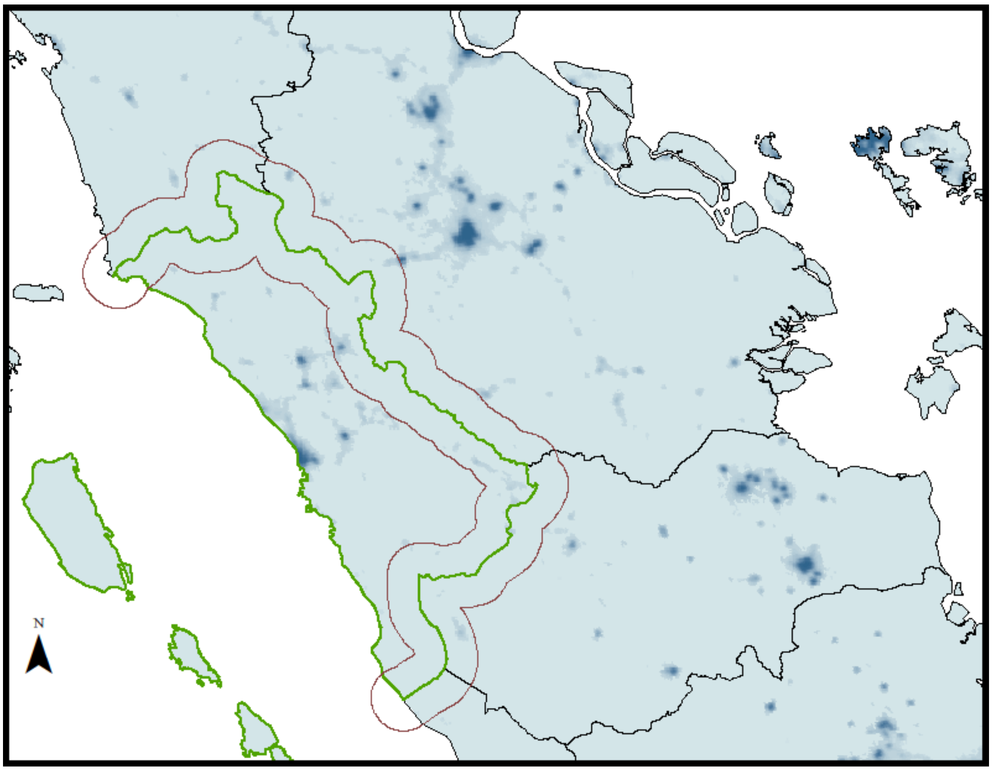
Figure 2: Development of Nighttime Light Intensity. (2008, 2009, and 2010)



Source: Author, original data NOAA (2012).

For this paper, we only focus on pixels that are located close to the border with West Sumatra. We created a band with a 60km width (30km on each side of the border) and only use pixels that fall within this band. Figure 3 shows the West Sumatra provincial border in green and the boundaries of the band in red.

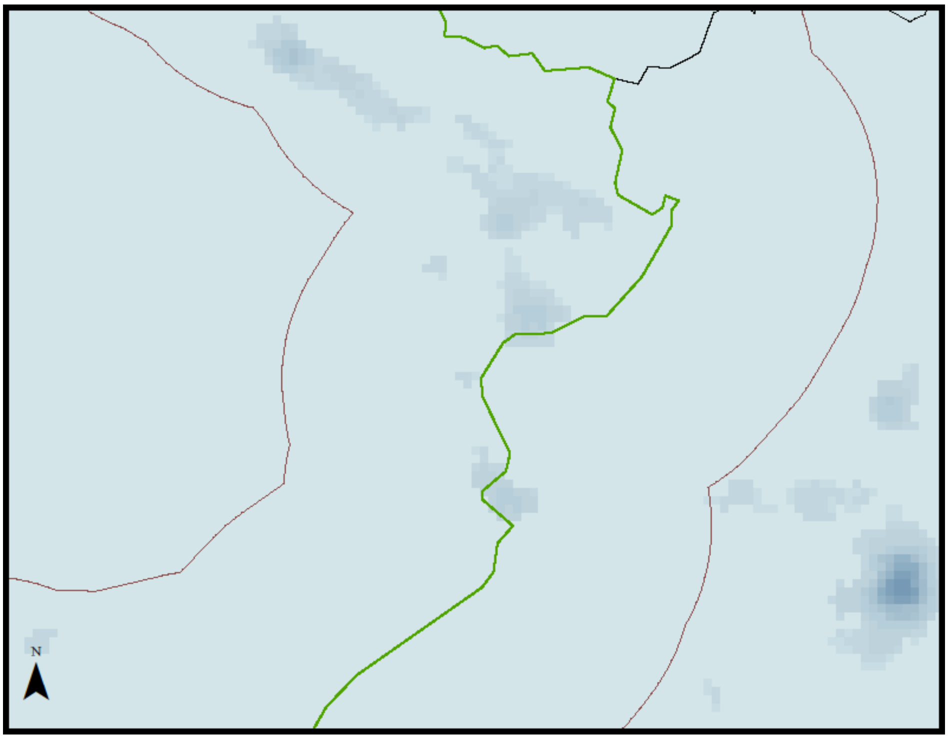
Figure 3: West Sumatra Border (green) and Band (red)



Source: Author, original data NOAA (2012).

Our unit observation is the pixel level. We only use pixels that were lit (pixel value > 0) in at least one of the three years of observation (2008, 2009, and 2010). Figure 4 provides a zoom of the map in Figure 3 of the border area between West Sumatra and Jambi. For this analysis, we only use lit pixels (the darker blue spots) that fall within the band (For example, those pixels in Jambi that are east of the red line are excluded). We then compare the pixels that are located within West Sumatra (those pixels in the area west of the green provincial border and east of the more western red line) with those located in Jambi (those pixels in the area east of the green provincial border and west of the more eastern red line).

Figure 4: Border area between West Sumatra and Jambi.



Source: Author, original data NOAA (2012).

Table 2 provides an overview of the number of observations per province. Using only pixels that had a value above 0 in at least once over the period 2008-2010 yields a total number of yearly observations of 2,594. 1,399 pixels (54%) are located in the treatment part of the band (Sumatera Barat).

Table 2: Number of Yearly Observations per Province

Province	No. of pixels per year
Bengkulu	55
Jambi	355
Riau	626
Sumatera Barat	1,401
Sumatera Utara	157

The individual pixel values are used and we construct to construct the variable *ln(light)* for each year, which is the log of the pixel value plus 0.01. To control for the damage each area suffered, we further construct *ΔLn(light08-09)* which is the difference between *Ln(light09)* and *Ln(light08).*

Table 3: Descriptive Statistics

	West Sumatra Province			***Other Provinces***		
Variable	**Obs.**	**Mean**	**Std. Dev.**	**Obs.**	**Mean**	**Std. Dev.**
Ln(light10)	1399	0.838	2.647	1195	0.741	2.844
Ln(light09)	1399	-2.479	3.065	1195	-1.518	3.285
Ln(light08)	1399	-0.192	2.970	1195	0.037	2.930
ΔLn(light08-09)	1399	-2.287	3.359	1195	-1.554	3.684

4. Empirical Strategy

The coverage of infrastructure through the West Sumatra public asset insurance program changes discretely at the province border. Public assets within the border of West Sumatra are covered by the insurance scheme, while public assets outside the province border are not covered by the insurance scheme. Given that the public asset insurance program treatment is a deterministic and discontinuous function of longitude and latitude, we can estimate the public insurance treatment effect on short-term recovery using a regression discontinuity approach.

$$\ln(light10)_{pi} = \alpha_o + \gamma INS_p + f(BD_{pi}) + X_{pi}\beta + \in_{pi}$$

where **X** is a vector of covariates that includes (depending on the specification) the log of light in 2008 and the log difference of the light values between 2008 and 2009 to capture the earthquake damage. $f(BD_{pi})$ is the RD polynomial, which controls for smooth functions of geographic location. The literature uses various forms. We define as the distance from each pixel i's centroid to West Sumatra's province border.

INS is our variable of main interest, which is a dummy variable that takes on the value one for pixels that are located in West Sumatra (and thereby potentially covered by the public asset insurance scheme) and zero if they are located in any of the other 4 affected provinces that do not have a public asset disaster insurance scheme in place. We interpret a positive γ as an indication that the public insurance scheme has a positive effect on short-term economic recovery in 2010.

Previous research has employed variants of this RD-type design to estimate the effect of institutional differences at the border on particular outcome variables. For example, Lee and Lemieux (2010) discuss the use of the discontinuity at the national borders to identify local average (treatment) effect in the quality of national institutions. Dell (2010) applies this RD-type design to analyze the long run effects of a forced labor system in South America. Michalopoulos and Papaioannou (2013) use a comparable estimation strategy in combination with pixel-level nighttime light intensity to estimate the effect of pre-colonial institutions on contemporary economic development.

The RD strategy in this paper exploits the discontinuity of insurance coverage at the province border of West Sumatra. Hence, our identifying assumption is that pixels that are located just around the geographical cut-off (West Sumatra province border) are very similar with respect to economic, climatic, topographic, demographic and institutional characteristics and only differ in their coverage by the public asset insurance scheme.

5. Results

Table 4 presents the main results of the RD analysis. In the first column, we examine the effect of the September 2009 earthquake by regressing the log of light in 2009 on the log of light in 2008, the insurance treatment dummy as well as the is the RD polynomial $f(BD_{pi})$. The negative and significant sign of INS indicates that the decrease in nighttime light intensity due to the earthquake was larger in West Sumatra then in the other affected provinces. Compared to the other provinces light intensity of the pixels within the band decreased by 8.7% in West Sumatra in 2009.

This result reflects that the epicenter of the earthquake was just off the coast of Padang and thereby the majority of pixels in the West Sumatra part of the band are geographically closer to the epicenter. It also highlights the importance of controlling for the differences in the experienced magnitude in the main regression. Otherwise, the treatment variable would be potentially downward biased because it also captures a higher exposure to the earthquake shock and thereby large destruction.

The second column presents the main specification estimating the impact of the insurance treatment on nighttime light in 2010, the year following the earthquake. The coefficient of *INS* is positive and statistically significant at the 5 %-level. The results indicate that increase in light intensity during the recovery year was on average 2.1% higher in pixels that are located in the West Sumatra province as compared to the other affected regions. In this specification, we also control for the differences in the earthquake damages using *ΔLn(light08-09)*.

The last column includes the level of light in 2008 as an additional control variable to capture the potential effect of differences in initial light endowment between pixels in the West Sumatra part of the band and pixels in the band covering all other provinces. The results stay robust and the size of the *INS* coefficient is very similar as compared to the specification in the second column.

One potential concern with these estimates could be that the federal government or international NGOs were aware of the existence of the public asset insurance scheme and adjusted their regional relief efforts accordingly. Thereby it is possible that West Sumatra received relatively less financial relief from the central government or NGOs.

Table 4: Main Results - Regression Discontinuity (RD) Estimates.

	Ln(light09) $_{pi}$	***Ln(light10)*** $_{pi}$	***Ln(light10)*** $_{pi}$
Ln(light08) $_{pi}$	0.368***		0.094***
	(0.018)		(0.013)
INS $_{pi}$	-0.087***	0.021**	0.027**
	(0.012)	(0.010)	(0.011)
ΔLn(light08-09) $_{pi}$		0.160***	0.202***
		(0.022)	(0.022)
Constant	-1.531***	0.990***	1.051***
	(0.091)	(0.093)	(0.091)
N	2594	2594	2594

Notes: All regressions include RD polynomial (the distance between the pixel's centroid and the West Sumatra province border). Robust standard errors (in parentheses). ***, **, and * indicate significance at the , 5 and 10 percent level, respectively.

6. Conclusion

This paper analyses the effect of the West Sumatra public asset insurance program on short-term economic recovery after the September 2009 West Sumatra Earthquake. We use satellite data on yearly differences in nighttime-light intensity as a proxy for economic activity, to investigate the effect of the earthquake damage on overall luminosity in 2009 and the progress in recovery in the year 2010. Our level of analysis is the pixel-level which corresponds to an area of about 0.8 km^2.

Our identification strategy consists of a regression discontinuity approach that compares differences between economic recovery of pixels that are located at the province border of West Sumatra. We estimate the difference in recovery progress (increase in light intensity in 2010) in areas that have been covered by the public insurance program (West Sumatra province) with those affected areas that did not have such an insurance scheme (Bengkulu, Jambi, Riau, and Sumatera Utara).

Considering that the West Sumatra insurance scheme only covers a small amount of public buildings, we still find that areas at the province border that are located in West Sumatra experience a 2.1% higher increase in light intensity in the year after the earthquake as compared to areas at the other side of the province border. Controlling for initial level of light intensity and the decrease in luminosity during the disaster year, we attribute these differences to the existence of an ex-ante insurance scheme.

Our results provide empirical support for the idea that ex-ante insurance scheme, even though the coverage is rather small, can have a positive effect on short-term recovery. Therefore, this paper provides an 'empirical complement' to existing theoretical arguments and anecdotal evidence that supports the positive effect of ex-ante risk-transfer mechanisms. As such, the West Sumatra public asset insurance scheme could be used a further case study for other subnational units across ASEAN countries to manage the financial risks associated with natural disasters more efficiently.

References

Besley, T. J and R. Burgess (2002), 'The Political Economy of Government Responsiveness: Theory and Evidence from India', *Quarterly Journal of Economics* 117(4), pp. 1415–1451.

Cavallo, E. and I. Noy (2009), 'The Economics of Natural Disasters: A Survey', *Research Department Publications 4649*, Inter-American Development Bank, Research Department.

Cavallo, E., S. Galiani, I. Noy, and J. Pantano (2013), 'Catastrophic Natural Disasters and Economic Growth', *Review of Economics and Statistics,* (*forthcoming*).

Coate, S. (1995), 'Altruism, the Samaritan's Dilemma, and Government Transfer Policy' *American Economic Review* 85(1), pp. 46–57.

Crespo Cuaresma, J., J. Hlouskova, and M. Obersteiner (2008), 'Natural Disasters as Creative Destruction? Evidence from Developing Countries', *Economic Inquiry,* 46(2), pp. 214–226.

Dell, M. (2010), 'The Persistent Effects of Peru's Mining Mita', *Econometrica* 78(6), pp. 1863-1903.

Dilley, Maxx, Chen, Robert S., Deichmann, Uwe, Lerner-Lam, Arthur L., Arnold, Margaret, Agwe, Jonathan, Buys, Piet, Kjekstad, Oddvar, Lyon, Bradfield, and Yetman, Gregory, (2005), 'Natural Disaster Hotspots: A Global Risk Analysis' *World Bank Disaster Risk Management Series* 5.

Elvidge, C. D., E. B. Kimberly, E. A. Kihn, H. W. Kroehl, E. R. Davis (1997), 'Mapping City Lights With Nighttime Data From the DMSP Operational Linescan System', *Photogrammetric Engineering and Remote Sensing,* 63, pp.727-734.

Elvidge, C. D., P. C. Sutton, T. Ghosh, B. T. Tuttle, K. E. Baugh, B. Bhaduri, E. Bright (2009), 'A Global Poverty Map Derived From Satellite Data', *Remote Sensing,* 1(3), pp.418-444.

Garrett, T. A. and R. S. Sobel (2003), 'The Political Economy of FEMA Disaster Payments', *Economic Inquiry* 41(3), pp.496–508.

Ghosh, T., S. Anderson, R. L. Powell, P. C. Sutton, and C. D. Elvidge (2009), 'Estimation of Mexico's Informal Economy and Remittances Using Nighttime Imagery', *Computers and Geosciences* 35(8), pp.1652-1660.

Hallegatte, S. and P. Dumas (2009), 'Can Natural Disasters Have Positive Consequences? Investigating the Role of Embodied Technical Change', *Ecological Economics*, 68(3), pp.777-786.

Hallegatte, S., J.-C. Hourcade, and P. Dumas (2007), 'Why Economic Dynamics Matter in Assessing Climate Change Damages: Illustration on Extreme Events', *Ecological Economics*, 62(2), pp.330–340.

Henderson, V. J., A. Storeygard, and D. N. Weil (2012), 'Measuring Economic Growth from Outer Space', *American Economic Review,* 102(2), pp.994-1028.

Hodler, R., and P. A. Raschky (2013), 'Regional Favouritism', *mimeo*, Monash University, Melbourne.

Lee, D. S. and T. Lemieux (2010), 'Regression Discontinuity Designs in Economics', *Journal of Economic Literature,* 48(2), pp.281-355.

Leiter, A. M., H. Oberhofer and P. A. Raschky (2009), 'Creative Disasters? Flooding Effects on Capital, Labor and Productivity within European Firms', *Environmental and Resource Economics*, 43(3), pp.333–350.

Loayza, N. V., E. Olaberría, J. Rigolini, L. Christiaensen (2012), 'Natural Disasters and Growth: Going Beyond the Averages', *World Development*, 40(7), pp.1317-1336.

Michalopoulos, S. and E. Papaioannou (2013), 'Pre-Colonial Ethnic Institutions and Contemporary African Development', *Econometrica* 81(1), pp.113-152.

Michel-Kerjan, E. and H. Kunreuther (2011), 'Policy Forum: Redesigning Flood Insurance', *Science* 333(22), pp.408–409.

Mustafa, D. (2003), 'Reinforcing Vulnerability? Disaster Relief, Recovery and Response to the 2001 Flood in Rawalpindi, Pakistan', *Environmental Hazards* 5, pp.71–82.

Raschky, P. A., R. Schwarze, M. Schwindt and F. Zahn (2013), 'Uncertainty of Governmental Relief and the Crowding out of Flood Insurance', *Environmental and Resource Economics* 54(2), pp.179–200.

Raschky, P. A., and H. Weck-Hannemann (2007), 'Charity Hazard—A Real Hazard to Natural Disaster Insurance?', *Environmental Hazards* 7(4), pp.321–329.

Skidmore, M., and H. Toya (2002), 'Do Natural Disasters Promote Long-run Growth?', *Economic Inquiry*, 40(4), pp.664–687.

Sutton, P. C. and R. Costanza (2002), 'Global Estimates of Market and Non-Market Values Derived from Nighttime Satellite Imagery, Land Use, and Ecosystem Service Valuation', *Ecological Economics* 41(3), pp.509-527.

Sutton, P. C., C. D. Elvidge, and T. Ghosh (2007), 'Estimation of Gross Domestic Product at Sub-National Scales Using Nighttime Satellite Imagery', *International Journal of Ecological Economics & Statistics,* 8(S07), pp.5-21.

ENDNOTES

[1] http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=43506

[2] http://earthquake.usgs.gov/earthquakes/eqinthenews/2009/us2009mfaf/

[3] http://www.thejakartapost.com/news/2010/01/08/west-sumatra-sets-deadline-complete-postquake-works.html

[4] http://www.ausaid.gov.au/HotTopics/Pages/Display.aspx?QID=471

[5] http://reliefweb.int/report/indonesia/usaidofda-indonesia-earthquake-fact-sheet-12-fy-2010

[6] http://eeas.europa.eu/delegations/indonesia/documents/eu_indonesia/aidindonesia_en.pdf

[7] http://reliefweb.int/sites/reliefweb.int/files/resources/Full_Report_3015.pdf

[8] Advancing Disaster Risk Financing and Insurance in ASEAN Member States: Framework and Options for Implementation. Technical Appendix.

[9] Munich-re TOPICS GEO Natural catastrophes 2009: Analyses, assessments, positions

[10] GFDRR (2011), *Advancing a National Disaster Risk Financing Strategy – Options for Consideration*

[11] http://www.maipark.com/content/display/tariff

[12] http://www.thejakartapost.com/news/2013/02/02/public-expenditure-regional-disaster-mitigation.html

ERIA Discussion Paper Series

No.	Author(s)	Title	Year
2013-35	Paul A. RASCHKY	Estimating the Effects of West Sumatra Public Asset Insurance Program on Short-Term Recovery after the September 2009 Earthquake	Dec 2013
2013-34	Nipon POAPONSAKORN and Pitsom MEETHOM	Impact of the 2011 Floods, and Food Management in Thailand	Nov 2013
2013-33	Mitsuyo ANDO	Development and Resructuring of Regional Production/Distribution Networks in East Asia	Nov 2013
2013-32	Mitsuyo ANDO and Fukunari KIMURA	Evolution of Machinery Production Networks: Linkage of North America with East Asia?	Nov 2013
2013-31	Mitsuyo ANDO and Fukunari KIMURA	What are the Opportunities and Challenges for ASEAN?	Nov 2013
2013-30	Simon PEETMAN	Standards Harmonisation in ASEAN: Progress, Challenges and Moving Beyond 2015	Nov 2013
2013-29	Jonathan KOH and Andrea Feldman MOWERMAN	Towards a Truly Seamless Single Windows and Trade Facilitation Regime in ASEAN Beyond 2015	Nov 2013
2013-28	Rajah RASIAH	Stimulating Innovation in ASEAN Institutional Support, R&D Activity and Intelletual Property Rights	Nov 2013
2013-27	Maria Monica WIHARDJA	Financial Integration Challenges in ASEAN beyond 2015	Nov 2013
2013-26	Tomohiro MACHIKITA and Yasushi UEKI	Who Disseminates Technology to Whom, How, and Why: Evidence from Buyer-Seller Business Networks	Nov 2013
2013-25	Fukunari KIMURA	Reconstructing the Concept of “Single Market a Production Base” for ASEAN beyond 2015	Oct 2013
2013-24	Olivier CADOT Ernawati MUNADI Lili Yan ING	Streamlining NTMs in ASEAN: The Way Forward	Oct 2013
2013-23	Charles HARVIE, Dionisius NARJOKO, Sothea OUM	Small and Medium Enterprises’ Access to Finance: Evidence from Selected Asian Economies	Oct 2013

No.	Author(s)	Title	Year
2013-22	Alan Khee-Jin TAN	Toward a Single Aviation Market in ASEAN: Regulatory Reform and Industry Challenges	Oct 2013
2013-21	Hisanobu SHISHIDO, Shintaro SUGIYAMA, Fauziah ZEN	Moving MPAC Forward: Strengthening Public-Private Partnership, Improving Project Portfolio and in Search of Practical Financing Schemes	Oct 2013
2013-20	Barry DESKER, Mely CABALLERO-ANTHONY, Paul TENG	Thought/Issues Paper on ASEAN Food Security: Towards a more Comprehensive Framework	Oct 2013
2013-19	Toshihiro KUDO, Satoru KUMAGAI, So UMEZAKI	Making Myanmar the Star Growth Performer in ASEAN in the Next Decade: A Proposal of Five Growth Strategies	Sep 2013
2013-18	Ruperto MAJUCA	Managing Economic Shocks and Macroeconomic Coordination in an Integrated Region: ASEAN Beyond 2015	Sep 2013
2013-17	Cassy LEE and Yoshifumi FUKUNAGA	Competition Policy Challenges of Single Market and Production Base	Sep 2013
2013-16	Simon TAY	Growing an ASEAN Voice? : A Common Platform in Global and Regional Governance	Sep 2013
2013-15	Danilo C. ISRAEL and Roehlano M. BRIONES	Impacts of Natural Disasters on Agriculture, Food Security, and Natural Resources and Environment in the Philippines	Aug 2013
2013-14	Allen Yu-Hung LAI and Seck L. TAN	Impact of Disasters and Disaster Risk Management in Singapore: A Case Study of Singapore's Experience in Fighting the SARS Epidemic	Aug 2013
2013-13	Brent LAYTON	Impact of Natural Disasters on Production Networks and Urbanization in New Zealand	Aug 2013
2013-12	Mitsuyo ANDO	Impact of Recent Crises and Disasters on Regional Production/Distribution Networks and Trade in Japan	Aug 2013
2013-11	Le Dang TRUNG	Economic and Welfare Impacts of Disasters in East Asia and Policy Responses: The Case of Vietnam	Aug 2013
2013-10	Sann VATHANA, Sothea OUM, Ponhrith KAN,	Impact of Disasters and Role of Social Protection in Natural Disaster Risk Management in Cambodia	Aug 2013

No.	Author(s)	Title	Year
	Colas CHERVIER		
2013-09	Sommarat CHANTARAT, Krirk PANNANGPETCH, Nattapong PUTTANAPONG, Preesan RAKWATIN, and Thanasin TANOMPONGPHANDH	Index-Based Risk Financing and Development of Natural Disaster Insurance Programs in Developing Asian Countries	Aug 2013
2013-08	Ikumo ISONO and Satoru KUMAGAI	Long-run Economic Impacts of Thai Flooding: Geographical Simulation Analysis	July 2013
2013-07	Yoshifumi FUKUNAGA and Hikaru ISHIDO	Assessing the Progress of Services Liberalization in the ASEAN-China Free Trade Area (ACFTA)	May 2013
2013-06	Ken ITAKURA, Yoshifumi FUKUNAGA, and Ikumo ISONO	A CGE Study of Economic Impact of Accession of Hong Kong to ASEAN-China Free Trade Agreement	May 2013
2013-05	Misa OKABE and Shujiro URATA	The Impact of AFTA on Intra-AFTA Trade	May 2013
2013-04	Kohei SHIINO	How Far Will Hong Kong's Accession to ACFTA will Impact on Trade in Goods?	May 2013
2013-03	Cassey LEE and Yoshifumi FUKUNAGA	ASEAN Regional Cooperation on Competition Policy	Apr 2013
2013-02	Yoshifumi FUKUNAGA and Ikumo ISONO	Taking ASEAN+1 FTAs towards the RCEP: A Mapping Study	Jan 2013
2013-01	Ken ITAKURA	Impact of Liberalization and Improved Connectivity and Facilitation in ASEAN for the ASEAN Economic Community	Jan 2013
2012-17	Sun XUEGONG, Guo LIYAN, Zeng ZHENG	Market Entry Barriers for FDI and Private Investors: Lessons from China's Electricity Market	Aug 2012
2012-16	Yanrui WU	Electricity Market Integration: Global Trends and Implications for the EAS Region	Aug 2012
2012-15	Youngho CHANG, Yanfei LI	Power Generation and Cross-border Grid Planning for the Integrated ASEAN Electricity Market: A Dynamic Linear Programming Model	Aug 2012

No.	Author(s)	Title	Year
2012-14	Yanrui WU, Xunpeng SHI	Economic Development, Energy Market Integration and Energy Demand: Implications for East Asia	Aug 2012
2012-13	Joshua AIZENMAN, Minsoo LEE, and Donghyun PARK	The Relationship between Structural Change and Inequality: A Conceptual Overview with Special Reference to Developing Asia	July 2012
2012-12	Hyun-Hoon LEE, Minsoo LEE, and Donghyun PARK	Growth Policy and Inequality in Developing Asia: Lessons from Korea	July 2012
2012-11	Cassey LEE	Knowledge Flows, Organization and Innovation: Firm-Level Evidence from Malaysia	June 2012
2012-10	Jacques MAIRESSE, Pierre MOHNEN, Yayun ZHAO, and Feng ZHEN	Globalization, Innovation and Productivity in Manufacturing Firms: A Study of Four Sectors of China	June 2012
2012-09	Ari KUNCORO	Globalization and Innovation in Indonesia: Evidence from Micro-Data on Medium and Large Manufacturing Establishments	June 2012
2012-08	Alfons PALANGKARAYA	The Link between Innovation and Export: Evidence from Australia's Small and Medium Enterprises	June 2012
2012-07	Chin Hee HAHN and Chang-Gyun PARK	Direction of Causality in Innovation-Exporting Linkage: Evidence on Korean Manufacturing	June 2012
2012-06	Keiko ITO	Source of Learning-by-Exporting Effects: Does Exporting Promote Innovation?	June 2012
2012-05	Rafaelita M. ALDABA	Trade Reforms, Competition, and Innovation in the Philippines	June 2012
2012-04	Toshiyuki MATSUURA and Kazunobu HAYAKAWA	The Role of Trade Costs in FDI Strategy of Heterogeneous Firms: Evidence from Japanese Firm-level Data	June 2012
2012-03	Kazunobu HAYAKAWA, Fukunari KIMURA, and Hyun-Hoon LEE	How Does Country Risk Matter for Foreign Direct Investment?	Feb 2012
2012-02	Ikumo ISONO, Satoru KUMAGAI, Fukunari KIMURA	Agglomeration and Dispersion in China and ASEAN: A Geographical Simulation Analysis	Jan 2012
2012-01	Mitsuyo ANDO and Fukunari KIMURA	How Did the Japanese Exports Respond to Two Crises in the International Production Network?: The Global	Jan 2012

No.	Author(s)	Title	Year
		Financial Crisis and the East Japan Earthquake	
2011-10	Tomohiro MACHIKITA and Yasushi UEKI	Interactive Learning-driven Innovation in Upstream-Downstream Relations: Evidence from Mutual Exchanges of Engineers in Developing Economies	Dec 2011
2011-09	Joseph D. ALBA, Wai-Mun CHIA, and Donghyun PARK	Foreign Output Shocks and Monetary Policy Regimes in Small Open Economies: A DSGE Evaluation of East Asia	Dec 2011
2011-08	Tomohiro MACHIKITA and Yasushi UEKI	Impacts of Incoming Knowledge on Product Innovation: Econometric Case Studies of Technology Transfer of Auto-related Industries in Developing Economies	Nov 2011
2011-07	Yanrui WU	Gas Market Integration: Global Trends and Implications for the EAS Region	Nov 2011
2011-06	Philip Andrews-SPEED	Energy Market Integration in East Asia: A Regional Public Goods Approach	Nov 2011
2011-05	Yu SHENG, Xunpeng SHI	Energy Market Integration and Economic Convergence: Implications for East Asia	Oct 2011
2011-04	Sang-Hyop LEE, Andrew MASON, and Donghyun PARK	Why Does Population Aging Matter So Much for Asia? Population Aging, Economic Security and Economic Growth in Asia	Aug 2011
2011-03	Xunpeng SHI, Shinichi GOTO	Harmonizing Biodiesel Fuel Standards in East Asia: Current Status, Challenges and the Way Forward	May 2011
2011-02	Hikari ISHIDO	Liberalization of Trade in Services under ASEAN+n : A Mapping Exercise	May 2011
2011-01	Kuo-I CHANG, Kazunobu HAYAKAWA Toshiyuki MATSUURA	Location Choice of Multinational Enterprises in China: Comparison between Japan and Taiwan	Mar 2011
2010-11	Charles HARVIE, Dionisius NARJOKO, Sothea OUM	Firm Characteristic Determinants of SME Participation in Production Networks	Oct 2010
2010-10	Mitsuyo ANDO	Machinery Trade in East Asia, and the Global Financial Crisis	Oct 2010
2010-09	Fukunari KIMURA Ayako OBASHI	International Production Networks in Machinery Industries: Structure and Its Evolution	Sep 2010

No.	Author(s)	Title	Year
2010-08	Tomohiro MACHIKITA, Shoichi MIYAHARA, Masatsugu TSUJI, and Yasushi UEKI	Detecting Effective Knowledge Sources in Product Innovation: Evidence from Local Firms and MNCs/JVs in Southeast Asia	Aug 2010
2010-07	Tomohiro MACHIKITA, Masatsugu TSUJI, and Yasushi UEKI	How ICTs Raise Manufacturing Performance: Firm-level Evidence in Southeast Asia	Aug 2010
2010-06	Xunpeng SHI	Carbon Footprint Labeling Activities in the East Asia Summit Region: Spillover Effects to Less Developed Countries	July 2010
2010-05	Kazunobu HAYAKAWA, Fukunari KIMURA, and Tomohiro MACHIKITA	Firm-level Analysis of Globalization: A Survey of the Eight Literatures	Mar 2010
2010-04	Tomohiro MACHIKITA and Yasushi UEKI	The Impacts of Face-to-face and Frequent Interactions on Innovation: Upstream-Downstream Relations	Feb 2010
2010-03	Tomohiro MACHIKITA and Yasushi UEKI	Innovation in Linked and Non-linked Firms: Effects of Variety of Linkages in East Asia	Feb 2010
2010-02	Tomohiro MACHIKITA and Yasushi UEKI	Search-theoretic Approach to Securing New Suppliers: Impacts of Geographic Proximity for Importer and Non-importer	Feb 2010
2010-01	Tomohiro MACHIKITA and Yasushi UEKI	Spatial Architecture of the Production Networks in Southeast Asia: Empirical Evidence from Firm-level Data	Feb 2010
2009-23	Dionisius NARJOKO	Foreign Presence Spillovers and Firms’ Export Response: Evidence from the Indonesian Manufacturing	Nov 2009
2009-22	Kazunobu HAYAKAWA, Daisuke HIRATSUKA, Kohei SHIINO, and Seiya SUKEGAWA	Who Uses Free Trade Agreements?	Nov 2009
2009-21	Ayako OBASHI	Resiliency of Production Networks in Asia: Evidence from the Asian Crisis	Oct 2009

No.	Author(s)	Title	Year
2009-20	Mitsuyo ANDO and Fukunari KIMURA	Fragmentation in East Asia: Further Evidence	Oct 2009
2009-19	Xunpeng SHI	The Prospects for Coal: Global Experience and Implications for Energy Policy	Sept 2009
2009-18	Sothea OUM	Income Distribution and Poverty in a CGE Framework: A Proposed Methodology	Jun 2009
2009-17	Erlinda M. MEDALLA and Jenny BALBOA	ASEAN Rules of Origin: Lessons and Recommendations for the Best Practice	Jun 2009
2009-16	Masami ISHIDA	Special Economic Zones and Economic Corridors	Jun 2009
2009-15	Toshihiro KUDO	Border Area Development in the GMS: Turning the Periphery into the Center of Growth	May 2009
2009-14	Claire HOLLWEG and Marn-Heong WONG	Measuring Regulatory Restrictions in Logistics Services	Apr 2009
2009-13	Loreli C. De DIOS	Business View on Trade Facilitation	Apr 2009
2009-12	Patricia SOURDIN and Richard POMFRET	Monitoring Trade Costs in Southeast Asia	Apr 2009
2009-11	Philippa DEE and Huong DINH	Barriers to Trade in Health and Financial Services in ASEAN	Apr 2009
2009-10	Sayuri SHIRAI	The Impact of the US Subprime Mortgage Crisis on the World and East Asia: Through Analyses of Cross-border Capital Movements	Apr 2009
2009-09	Mitsuyo ANDO and Akie IRIYAMA	International Production Networks and Export/Import Responsiveness to Exchange Rates: The Case of Japanese Manufacturing Firms	Mar 2009
2009-08	Archanun KOHPAIBOON	Vertical and Horizontal FDI Technology Spillovers:Evidence from Thai Manufacturing	Mar 2009
2009-07	Kazunobu HAYAKAWA, Fukunari KIMURA, and Toshiyuki MATSUURA	Gains from Fragmentation at the Firm Level: Evidence from Japanese Multinationals in East Asia	Mar 2009
2009-06	Dionisius A. NARJOKO	Plant Entry in a More LiberalisedIndustrialisationProcess: An Experience of Indonesian Manufacturing during the 1990s	Mar 2009

No.	Author(s)	Title	Year
2009-05	Kazunobu HAYAKAWA, Fukunari KIMURA, and Tomohiro MACHIKITA	Firm-level Analysis of Globalization: A Survey	Mar 2009
2009-04	Chin Hee HAHN and Chang-Gyun PARK	Learning-by-exporting in Korean Manufacturing: A Plant-level Analysis	Mar 2009
2009-03	Ayako OBASHI	Stability of Production Networks in East Asia: Duration and Survival of Trade	Mar 2009
2009-02	Fukunari KIMURA	The Spatial Structure of Production/Distribution Networks and Its Implication for Technology Transfers and Spillovers	Mar 2009
2009-01	Fukunari KIMURA and Ayako OBASHI	International Production Networks: Comparison between China and ASEAN	Jan 2009
2008-03	Kazunobu HAYAKAWA and Fukunari KIMURA	The Effect of Exchange Rate Volatility on International Trade in East Asia	Dec 2008
2008-02	Satoru KUMAGAI, Toshitaka GOKAN, Ikumo ISONO, and Souknilanh KEOLA	Predicting Long-Term Effects of Infrastructure Development Projects in Continental South East Asia: IDE Geographical Simulation Model	Dec 2008
2008-01	Kazunobu HAYAKAWA, Fukunari KIMURA, and Tomohiro MACHIKITA	Firm-level Analysis of Globalization: A Survey	Dec 2008