ERIA-DP-2021-44

ERIA Discussion Paper Series
No. 411

Market Entry, Survival, and Exit of Firms in the Aftermath of Natural Hazard-related Disasters: A Case Study of Indonesian Manufacturing Plants

Arlan BRUCAL[#§]
University of Exeter Business School, Exeter

Shilpita MATHEWS
London School of Economics and Political Science, London

December 2021

Abstract: *By combining plant-level data from the Indonesian Manufacturing Survey and localised disaster data from the Emergency Events Database for the period 1990–2015, we were able to exploit both temporal and spatial variation to investigate the global market entry, survival, and exit of plants in the aftermath of a major flood event at the kabupaten (regency) level. Results from the combined propensity score matching and difference-in-difference approach suggest no strong evidence of instantaneous and persistent detrimental effects of initial experience of flooding on overall and female employment, but with delayed effect on output and output per worker. Plants that are connected and foreign-owned experienced a persistent decline in output per worker relative to their domestic counterparts in the aftermath of a flooding event. On average, flooding was not found to have a significant impact on plant entry. The results highlight that international trade has unintended consequences for firm resilience to flooding. Trade-offs and complementarities between globalisation and other SDGs, such as gender equality and poverty reduction, are discussed.*

***Keywords*: Development; Flooding;** Globalisation; Indonesia; Resilience; Sustainable development; Trade.

***JEL Classification*:** F18; F23; Q56; O19

[#] Corresponding author: Arlan Brucal, address: University of Exeter Business School, Rennes Dr, Exeter EX4 4PU, United Kingdom. E-mail: A.Brucal@exeter.ac.uk

[§] This research was conducted as a part of the project of Economic Research Institute for ASEAN and East Asia (ERIA) Microdata Research Project for Fiscal Year 2020 on 'Global Market Entry, Survival, and Exit of Firms: Understanding the Process and the Effects'. The authors are deeply indebted to the members of this project for their invaluable suggestions. The opinions expressed in this paper are the sole responsibility of the authors and do not reflect the views of ERIA.

1. Introduction

As the frequency, intensity, and scale of natural hazard-related disasters increase over time, it is important to have in-depth knowledge of how this affects globalisation (Tembata and Takeuchi, 2019), ‘Disaster response plays a critical role in determining global market entry, survival, and exit of firms (Barthel and Neumayer, 2012), ‘Whilst economic losses from the coronavirus disease (COVID-19) have been a wake-up call for improving business resilience, global value chains remain unprepared for natural hazard-related, disaster-induced shocks (IMF, 2020; McKinsey Global Institute, 2020), ‘

Flooding risks determine firms’ ability to, for instance, engage in global activities through trade, foreign investment, and research and development (R&D) (Surminski and Tanner, 2016), ‘Firms can decide to continue or cease operations in the aftermath of disasters, posing systemic risks to the global financial system (Mandel et al., 2020), ‘Firms in developing countries are worst hit and suffer the greatest disaster losses (Stéphane Hallegatte et al., 2016; Loayza et al., 2012; Raddatz, 2009), ‘This has significant implications for Association of Southeast Asian Nations (ASEAN) Member States (AMSs), where firms play a central role in an economy’s globalisation process and total traded goods account for 93% of the region’s gross domestic product (GDP) (Tembata and Takeuchi, 2019).

Flooding is the most frequent occurring disaster in AMSs, causing highest damages and economic losses (Tembata and Takeuchi, 2019), ‘Indonesia remains particularly vulnerable due to increases in future flood risk (Winsemius et al., 2016) and development trajectories (Hiles, 2010), ‘Flooding causes significant economic losses, accounting for 99.3% of losses from all natural hazard-related damages between 2002–16 (Ishiwata et al., 2020), ‘Losses at the provincial level can account for 45% of GDP, with majority losses in industrial infrastructure damage (Global Facility for Disaster Reduction and Recovery, 2019), ‘Flooding also results in a high number of casualties, with flooding accounting for the highest numbers out of all the other natural hazard-related disasters in Indonesia from 2015–16 (BPS, 2017), ‘Even though the majority of infrastructure is owned by firms, investment in adaptation remains low (P. Pauw and Pegels, 2013), ‘Impacts can persist, with firms taking years to recover (Cole et al., 2019), ‘Importantly, natural hazard-related disasters can jeopardise international trade and investment gains made in Indonesia, which include reduced wage inequality, increased labour absorption, women’s participation in labour markets (Verico and Pangestu, 2020), and technological progress in the manufacturing sector (Kuncoro, 2012), ‘Thus, disasters may have negative repercussions for sustainable development objectives. To this end, this paper will study market entry, survival, and exit of firms in the aftermath of natural hazard-related disasters by answering the following research questions:

1. How does flooding impact the process of global market entry, survival, and exit of manufacturing plants?
2. What characteristics determine the continuation of global activities of manufacturing plants in the aftermath of flooding?
3. How do the long-term recovery pathways of manufacturing plants impact the achievement of sustainable development objectives?

There are four objectives driving the research questions. First, whilst there is growing literature considering the impacts of globalisation (Verico and Pangestu, 2020; Wagner, 2013) and natural hazard-related disasters (Cole et al., 2019; Elliott et al., 2019; Neise and Diez, 2019) on firm behaviour, there have been limited attempts to link these together. Traditional globalisation models may be simplistic for the purpose of explaining firms’ market entry decisions and subsequent survival. Disaster shocks can affect firm economic performance and competitiveness, leading to long-term restructuring of the entire industry. Moreover, natural hazard-related disasters can have unintended consequences on other sustainable development goals (SDGs) (Echendu, 2020), rendering lessons for gender equality (Yumarni and Amaratunga, 2015), as well as energy policy (IDB, 2020) and environmental safeguards[1] (Van Veen-Groot and Nijkamp, 1999).

Second, Battisti and Deakins (2017) suggested empirical analysis can contribute to theory development, given that plant-level data are infrequently used to make interdisciplinary connections across the disaster resilience and industrial organisation

[1] Environmental safeguards in this context refer to policies to mitigate the detrimental environmental impacts of global trade. This can include the activities of global firms, as well as supply chains and transport infrastructure (ADB, 2020).

literature. This is particularly true for developing countries such as Indonesia. Focusing on manufacturing plants provides an apt case study, given their significance to the Indonesian economy (Neise and Diez, 2019), high economic losses, and exposure to disasters (Budiyono et al., 2016), ‘Moreover, plant-level data are superior to firm-level data due to their direct link to production, employment, and global value chains.

Third, there is debate within the empirical literature on the effects of disasters on firm economic performance. For instance, the widely known process of market entry may be longer and varied in the context of natural hazard-related disasters (Elliott et al., 2019), ‘Moreover, studies in manufacturing remain limited (Liu et al., 2013), ‘It is hoped that studying performance, alongside persistence of effects, will overcome ambiguity in evidence and give insights into longer-term recovery pathways.

Finally, investigating firm heterogeneity renders policy lessons for continuation of foreign direct investment (FDI)-led activities (Ambrosini et al., 2009), ‘For instance, various pre-entry determinants are likely related to plant survival and exit in the aftermath of disasters. In the wake of COVID-19, the extent of damages to firms from economic shocks is evident (Sumner et al., 2020), ‘However, the distribution of losses, especially in the case of disaster-induced shocks, is unknown. To this end, results will help firms, governments, and investors devise appropriate policies as part of a broader globalisation and disaster adaptation strategy.

2. Literature Review

Literature gaps are identified in three specific areas, which are addressed in this paper.

2.1. The effect of natural hazard-related disasters on firm global market entry, survival, and exit is unclear.

Globally, economic losses from natural hazard-related disasters account for US$150–200 billion annual damage (Surminski and Tanner, 2016), ‘The extent to which disasters arising from natural hazards, such as flooding events, affect international supply chains has been witnessed in the 2011 Thailand floods, which led to a global shortage in computer components and caused the highest number of losses in the manufacturing sector (Anuchitworawong and Thampanishvong, 2015; Chongvilaivan, 2012; Davis and

Alexander, 2015; Pathak and Ahmad, 2016; Tembata and Takeuchi, 2019), ‘In Indonesia, flooding costs approximately US$430 million in losses annually (ADB, 2016), ‘Mandel et al. (2020) listed Indonesia amongst the top 10 countries in terms of total financial loss from flooding. Accounting for domestic impact and global propagation to financial networks, river flooding in Indonesia alone has had an impact of 3.8% basis points (0.01%) of world GDP. This is expected to increase to 8.6% by 2080 without adaptation. Despite these estimations, it is unclear how losses are manifested at the micro level and impact global market connectivity.

Moreover, emphasis on firms is lacking (Battisti and Deakins, 2017; Liu et al., 2013; Zhang et al., 2009), ‘This evidence is critical in Indonesia given that manufacturing firms are the backbone of its globalisation process (Neise and Diez, 2019), ‘There are strong firm incentives to operate efficiently, recover quickly, and maintain survival (Rose, 2016), ‘However, existing evidence is conflicting.

Firms’ market entry, survival, and exit depends on pre-existing international market and trade connectivity. For example, in the case of damaged transport routes, firms with limited suppliers have higher probability of impact (Hallegatte, Bangalore, and Jouanjean, 2016), ‘Damages to plants providing key input can cause sector-wide production shocks (Barrot and Sauvagnat, 2016), ‘There are numerous studies investigating the impacts of natural hazard-related disasters on exports (Chongvilaivan, 2012; Elliott et al., 2019; Miyakawa et al., 2016; Tembata and Takeuchi, 2019), FDI (Anuchitworawong and Thampanishvong, 2015; Cole et al., 2017), and global supply chains (Altay and Ramirez, 2010; Basker and Miranda, 2018; Chongvilaivan, 2012; Hamaguchi, 2013; Thorbecke, 2016).

Elliott et al. (2019) noted a divergence in terms of foreign and domestic linkages. They found that domestic sales fall more significantly than foreign exports after a disaster. This is attributed to damaged local infrastructure and reduced domestic demand. Therefore, firms with foreign sales are less vulnerable to disasters. Moreover, there is an increase in exports post-disaster, which may be due to a shift in customer base (to undamaged local competitors) or a strategy to mitigate future risk. Conversely, there is a decrease in imports in the aftermath of a disaster, attributed to damaged transport links. Firms importing supplies are most affected, since locally sourced firms maintained their inputs post-disaster. Reduction in imports is consistent with other studies in the literature

(Gassebner et al., 2010; Oh and Reuveny, 2010), ‘Nonetheless, Tembata and Takeuchi’s 2019 analysis of flooding impacts on agricultural and manufacturing exports in Southeast Asia demonstrates a 3%–5% immediate decline in exports, followed by persistent annual loss of 2% of export values on average. This is consistent with other estimated export declines in the aftermath of flooding (Hadri et al., 2017), ‘

Moreover, in a study of manufacturing plant survival in Germany, Wagner (2013) demonstrated that, whilst exporters are more likely to survive, this was in combination with other characteristics like importing materials. Thus, characteristics must be viewed in tandem with each other. Regardless of impacts to business premises, exports can also be affected due to reliance on critical infrastructure damage. For example, Miyakawa et al. (2016) found that, in the case of both damaged and undamaged firms in the aftermath of an earthquake, those transacting via a damaged bank were less likely to expand export destinations and had lower export-to-sales ratio, posing financial constraints.

Another indicator of international market linkage is the difference between foreign and domestic firm ownership. This indicator has not been studied in the context of natural hazard-related disasters but is expected to have economic divergence as per Brandt, Van Biesebroeck, and Zhang (2012) and Brucal, Javorcik, and Love (2019), ‘Even though foreign-owned plants may perform better than other flooded plants, flooding may have long-run negative effects. For example, Anuchitworawong and Thampanishvong (2015) found that foreign ownership leads to quicker recovery, but frequent disaster exposure reduces long-run FDI in Thailand. This has notable repercussions for sustainable objectives, as they found a positive relationship with FDI flows and economic development.

Finally, Basker and Miranda (2018) found that being part of a large supply chain minimised economic impact and expedites recovery. The interdependency of firms through supply chains is evident in the recent supply chain shocks resulting from COVID-19 (Ivanov and Dolgui, 2020), ‘It has also been explored in the context of AMSs, as seen in the case of Thailand’s 2011 floods, where Chongvilaivan (2012) highlighted the need for greater supply chain flexibility in view of just-in-time procurement channels and dependence on single suppliers. This has global ramifications, given that 70% of AMS exports go outside of the ASEAN region (Tembata and Takeuchi, 2019), ‘Specifically, 50% of Indonesian exports are from the manufacturing sector, which is studied in this paper.’ (Rodríguez-Pose et al., 2013)

Impact on international connectivity is based on numerous firm characteristics such as average number of suppliers, degree of complementarity, shape and structure of the industry (Henriet et al., 2012), and position in the supply chain (Altay and Ramirez, 2010; Hanger et al., 2018; Strobl, 2019), ‘For example, firms may have greater resilience due to their ability to find new customers or capture market share (Henriet et al., 2012), ‘Conversely, firms may experience contagion effects (ADB, 2016; Hiles, 2010; Rose, 2016), or cascading interdependencies, when multiple firms are hit by the same disaster. To this end, plant-level data in this paper enable analysis of direct employment and production impact on supply chains. Moreover, this paper is different from studies like Hu et al. (2019), who considered a closed economy model. The first research question will address these controversies related to global market performance.

2.2. The extent to which natural hazard-related disasters affect continuation of global activities depends on firm characteristics. Whilst both have been studied independently, no explicit links have been made.

Firm resilience, or the ability to cope with disasters, is a factor of hazard, exposure, and vulnerability (Rose, 2016), ‘Asset losses are significant, but it is hard to estimate how they translate to income losses (Hallegatte et al., 2016), ‘Welfare losses are greater, possibly through employment or future income streams (Hallegatte, 2008), ‘Moreover, indirect losses can exceed direct losses at the country level, especially when the country has low levels of economic resilience (PreventionWeb, 2015).

This paper will consider the vulnerability of firms, given a certain level of hazard and exposure (type of disaster as well as industry and location), ‘Thus, losses are not only dependent on production capacity but on firms’ vulnerability. For floods, this includes infrastructure quality, asset composition, insurance penetration, and ability to replace capital (Coelli and Manasse, 2014; Hallegatte et al., 2016), ‘

Factors like location (Scor SE, 2013), industry (Altay and Ramirez, 2010; Mandel et al., 2020), firm size (Craioveanu and Terrell, 2016) and supply chain linkages (Basker and Miranda, 2018) can determine recovery tactics employed by plants, like import substitution or management effectiveness (Dormady et al., 2019), ‘Some firm-level studies find negative economic performance after disasters in the manufacturing industry (Altay and Ramirez, 2010; Elliott et al., 2019), particularly when lost capital is not replaced (Hu et al., 2019), 'Recovery tactics in turn affect the overall recovery time, which has been found to be between 1 to 7 years, depending on disaster type, impact mechanism, and firm heterogeneity (Cole et al., 2019; Elliott et al., 2019), 'A similar short-term lag of 1 to 2 years has been found in entrepreneurship and start-up activity in the aftermath of natural hazard-related disasters in low-middle-income countries (Boudreaux et al., 2019), '

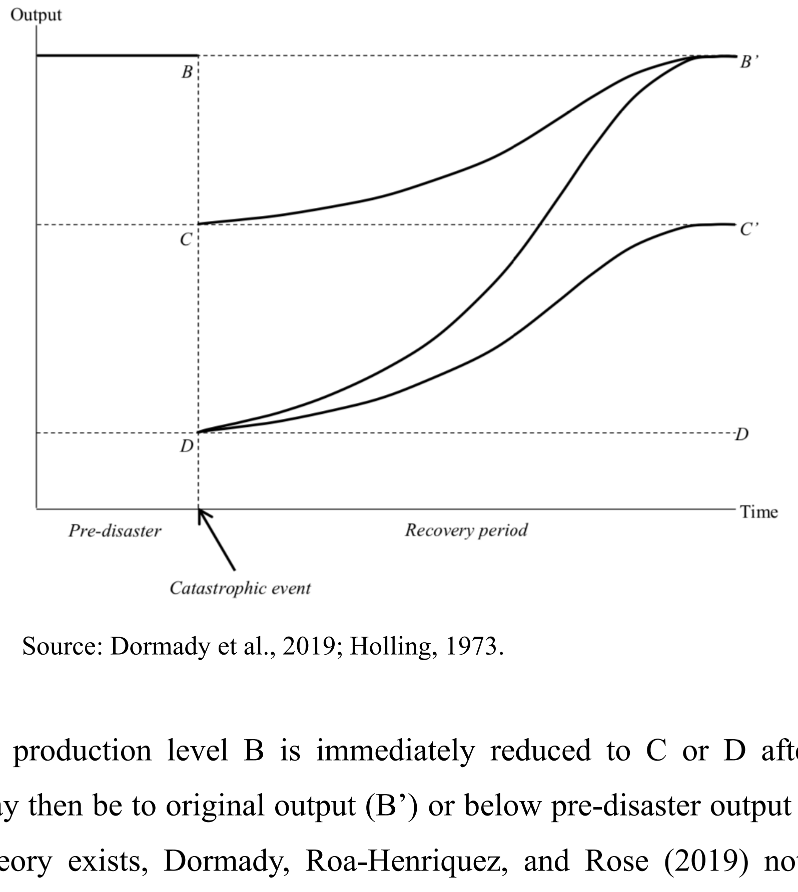
However, others indicate asset damage can lead to Schumpeterian creative destruction (Leiter et al., 2009), building on the seminal work of Dacy and Kunreuther (1969) who found positive GDP growth in the immediate aftermath of natural disasters. This is due to positive 'build back effects', a period of reconstruction during which firms undertake capital stock replacement, technology adoption, and human capital investment, and create resilient infrastructure (Battisti and Deakins, 2017; Hu et al., 2019; Skidmore and Toya, 2002), 'Thus, post-disaster environments can be viewed as transient advantage economies (Battisti and Deakins, 2017; McGrath, 2013), 'However, Crespo Cuaresma, Hlouskova, and Obersteiner (2008) showed that this form of creative destruction is limited in developing countries.

Firm characteristics and the channels through which disasters impact firms will be studied to gauge impact on global market activities.

2.3. Whilst the persistence of economic shocks has been explored, evidence is nascent for firm recovery pathways in the aftermath of disasters. This can have unintended consequences to sustainable development objectives.

The period of business interruption 'begins at the point of the shock and continues until the economy has recovered' (Rose, 2009), 'Business interruption has been extensively studied for economic shocks at the firm level, evidenced in the case of oil (Kilian and Park, 2009), 'However, evidence for natural hazard-related disasters remains sparse, predominantly due to lack of quantification (PreventionWeb, 2015), 'Macroeconomically, Hallegatte (2008) found that, after US$50 billion losses, the reconstruction period extends, and indirect losses increase significantly. There is also low consensus on longevity of effects. Recovery time has been found to be between 1 to 7 years, depending on hazard type and firm heterogeneity (Cole et al., 2019; Elliott et al., 2019), ‘Recovery pathways also depend on the types of shocks experienced. For instance, a capital shock can make sourcing inputs expensive post-disaster. This may lead to industry reconfiguration from foreign to domestic firm domination, as found by Kato and Okubo (2018), ‘Dynamic resilience can be studied by considering attributes (inherent resilience) and activities (adaptive resilience) which dampen business interruption (Rose, 2009), ‘Firms can take different recovery paths, as seen in Figure 1.

Figure 1. Resilience in Firm Recovery



Source: Dormady et al., 2019; Holling, 1973.

Here, production level B is immediately reduced to C or D after a disaster. Recovery may then be to original output (B’) or below pre-disaster output (C’), ‘Whilst no single theory exists, Dormady, Roa-Henriquez, and Rose (2019) noted that it is important to study reduction in flows of goods and services as opposed to stock damage.

Empirically, Coelli and Manasse (2014) demonstrated build-back effects, a period of reconstruction during which firms undertake capital stock replacement and human capital investment, leading to short-term growth (Battisti and Deakins, 2017; Hu et al., 2019; Skidmore and Toya, 2002), 'Conversely, Hu et al.'s 2019 results indicate lagged effects 2 years after a flood, which account for 5.4% of additional losses at the plant level. However, evidence may be rooted in survival bias, as the weakest plants exit the market following a disaster. The most competitive plants could dominate the industry subsequently (Cole et al., 2008), 'Given these contradictions in the literature, firm recovery pathways can have unintended consequences for development objectives.

For instance, there may be interactions between globalisation, gender, and disasters. Verico and Pangestu (2020) found that globalisation has increased female workforce participation, contributed to poverty alleviation, and reduced wage inequality in Indonesia. This progress could be compromised in the wake of disasters. Natural hazard-related disasters disproportionately impact women (Atela et al., 2018; Echendu, 2020; Yumarni and Amaratunga, 2015), 'As per Atela, Gannon, and Crick (2018), sociocultural orientations around gender roles mean female-led firms continue to face more barriers when building resilience, making them more vulnerable to disasters and delaying recovery. Moreover, the impact on female employment, as opposed to ownership, has not been distinguished. Diverging results also exist for female-headed households, as the FAO (2016) found they are more resilient to disasters. Such gender disparity has also been seen in the disaster resilience literature (Cao et al., 2019), 'Thus, the third research question will address the controversies around post-disaster firm recovery pathways, and implications for sustainable development in the context of globalisation.

This paper assesses the above gaps via the following means:

1. Examining how floods affect global market entry, survival and exit using firm exporting and foreign ownership status as indicators. These variables will be used to determine divergence in economic output, employment, and labour productivity. Foreign ownership has not been investigated previously but is hypothesised to be correlated with exporting status.
2. Exploring heterogeneity of effects controlling for plant characteristics. A valid counterfactual will be established to examine whether variables of interest diverge over time.
3. Investigating the link between plant recovery pathways, global market participation and the achievement of sustainable development objectives. Divergence in female

employment will be studied. Whilst this factor has not been previously explored, it is expected to have repercussions for the achievement of the SDGs.

3. Data

High frequency and exposure to natural hazard-related disasters makes Indonesia a relevant case study. Thus, a unique plant-level panel dataset from the Indonesian Manufacturing Survey is used. The main data source is Industri Besar dan Sedang (IBS), the Annual Indonesian Survey of Manufacturing for Medium and Large Enterprises maintained by the National Statistical Office (BPS, 2015).[2] The dataset covers all manufacturing plants with 20 or more employees on an annual basis since 1975. The survey has detailed information on plant-level production output, capital (measured in end-of-year value of whole fixed capital stock), employment (also disaggregated into employment by gender and low/high skills), and value added. The industrial classification used in the manufacturing industry survey is a classification based on the International Standard Industrial Classification of all Economic Activities (ISIC) revision 4, which has been adapted to conditions in Indonesia in 2009. We have access to the 1990–2015 sample period, which covers 63,382 plants with 525,111 plant-year observations.

Plants are grouped into 5-digit industry classifications based on the Indonesian Standard Classification of Business Fields, or 'Klasifikasi Baku Lapangan Usaha Indonesia', which is compatible with ISIC Rev 3. For the survey period, the data cover 24 sectors based on 2-digit ISIC. Nominal figures are deflated to reflect costs in 2015 Indonesian rupiah (IDR) using the national consumer price index.[3]

The use of panel data is an important contribution given limitations of previous

[2] The Annual Large-Medium Industry Survey (IBS) is conducted in full to all large and medium-sized industrial companies listed in the BPS Industrial Directory (complete enumeration), 'Large and Medium Industrial Companies covered in the Annual IBS survey are companies that have a workforce of 20 people or more, including industrial companies that have just started commercial production. The following types of plants do not appear in the IBS sample: plants not participating in the market, plants with less than 20 employees, plants not in the manufacturing sector, plants not participating in the survey and those recorded in the BPS directory (e.g., informal plants).

[3] We understand that it is preferable to deflate prices using ISIC 2-digit, industry-specific wholesale price index. However, we do not have access to this data at the time of writing. We address this issue by including industry-year fixed effects in all our specification involving sales-related variables.

studies. For instance, Leiter et al. (2009) faced simultaneity bias (input factors are affected by productivity), which was corrected using instrumental variables, though the use of panel data would be superior. Moreover, the near-census nature of the data allows us to explore market entry and exit based on when we first and last, respectively, observe the plants in the data.

Table 1 presents the summary statistics. 23% of the plant-year observations have recorded flood events. We also observe 12% of the observations associated with plant exits while only about 9% is associated with plant entry. Both variables, including the variable of interest and the outcome variables, have substantial variation to identify the effect.

Table 1: Summary Statistics

Variables	N	Mean	SD
Flood = 1, 0 else	525,111	.232	.422
No. of flood events	525,111	.236	.435
Output ('000 IDR)	525,056	97,144	873,048
No. of employees	525,111	196	733
Capital ('000 IDR)	525,090	7,823	1,314,158
Labour productivity	525,101	12,880	201,195
No. of female employees	477,471	95.2	499
No. of blue-collar employees	479,045	145	628
Importer=1, 0 else	525,111	.203	.402
Exporter =1, 0 else	493,707	.155	.362
Foreign owned = 1, 0 else	525,111	.0638	.244
Plant exit = 1, 0 else	525,111	.120	.325
Plant entry = 1, 0 else	525,111	.088	.283
No. of unique plants	63,382		
Year coverage	1990–2015		
No of observations	525,111		

N = number, SD = standard deviation.
Source: IBS.

Studies of disaster impacts at the plant level are scarce in the literature (Elliott et al., 2019), and give an added advantage of understanding immediate production shocks and appropriate recovery mechanisms. The large panel size adds to the validity of this paper, as compared to existing evidence in the literature (Coelli and Manasse, 2014), ' A sectoral approach lends itself well to policy lessons since national disaster planning is at this level (Surminski and Tanner, 2016), ‘A focus on manufacturing is critical given that it is disproportionately affected by natural disasters. Manufacturing plants are often located within coastal and urban areas that are most exposed to floods (Elliott et al., 2019; Neise and Diez, 2019; Rodríguez-Pose et al., 2013), ‘For example, Budiyono et al. (2016) estimated one-third of flood damages in Jakarta were experienced by the manufacturing sector, which is expected to increase to 47% by 2030.

Floods will be studied since impacts are more localised than other disasters, affecting fewer producers (Henriet et al., 2012; Koks et al., 2019), ‘Moreover, flooding is the most frequently occurring disaster in Indonesia (ADB, 2016; Neise and Diez, 2019) but firm responses have not been assessed quantitatively. Flood intensity is not included as variance is likely to have negligible effects for the purposes of this study. For instance, the IMF (2020) found, despite an increase in hazard strength and exposure damages in terms of GDP, economic losses have not significantly increased over time. Furthermore, in most cases, the impact on firms due to natural disasters is attributed to exposure as opposed to intensity of the disaster (McKinsey Global Institute, 2020; Xie et al., 2015), ‘

Flooding data for this paper are obtained from the Emergency Events Database (EM-DAT) database. The EM-DAT is a robust dataset with 22,000 disasters recorded worldwide, updated by numerous sources such as government, NGOs, and insurers. It has frequently been utilised in the disaster literature (Anuchitworawong and Thampanishvong, 2015; Hadri et al., 2017; Oh and Reuveny, 2010; Tembata and Takeuchi, 2019), ‘The dataset spans from the 1900s, but we will restrict the sample to the 1990s for quality purposes.

Flooding data are localised at the *kabupaten* (regency) level using a concordance matching coordinates where available to current regency data (*Kode Pos Indonesia*, 2020), ‘Using a concordance is essential to ensure historical *kabupaten* re-classification is accounted for in the dataset. Studying impact at the *kabupaten* level is helpful as initial government disaster response is mandated at this level (Global Facility for Disaster Reduction and Recovery, 2019), ‘The use of a concordance has been commonly applied when working with this dataset (Rodríguez-Pose et al., 2013), ‘Heterogeneity will be studied based on plant exporting, importing, and foreign ownership status. In addition, the divergence in female employment will be studied to determine the development consequences of plant recovery.

4. Main Analysis: Empirical Strategy

In order to explore the research questions, we use a Cox-proportional hazard approach to test whether impact of a disaster is dynamic in nature. Based on initial results, it is hypothesised that plants may not be following a linear path, with initial building back effects leading to potential quadratic recovery paths. In a similar vein, we combine Propensity Score Matching (PSM) with a difference-in-difference (DiD) approach to establish a valid counterfactual and explore recovery path divergence between flooded and non-flooded plants at the *kabupaten* level.

4.1 Market entry

In considering the effect of flood events on plant entry, we estimate the following regression:

$$E_{jt} = X\theta + \alpha_k + \lambda_t + u_{it}$$

where α_k and λ_t are *kabupaten*- and year-fixed effects, respectively. Vector X contains the *kabupaten*-level flood dummy that turns to unity when there is at least one flood event in the *kabupaten k* at year *t*, and the number of plants, their average age, and the number of industries (as measured by the number of unique 5-digit ISIC) within the *kabupaten*. The variables can control for non-random differences in these variables across *kabupatens* over time, which can be related to differences in local competition, level of advancement, agglomeration, or inter-industry linkages. Our variable of interest, E_{jt}, is the number of plant entries occurred in *kabupaten k* at year *t*+1. The equation is estimated using a fixed effects Poisson regression to account for the count nature of the data. We define market entry as entry into the survey. In other words, this is when a new plant is started or a pre-existing plant exceeds the 20 employees threshold, as defined by Hallward-Driemeier et al., (2017) who worked with the same Indonesian manufacturing survey data.

4.2 Market exit

Market exit occurs when there is plant closure, relocation, or a plant drops below the 20-employee threshold, as defined by Hallward-Driemeier et al., (2017), 'To determine whether flood events have any detrimental effect on a plant's survival, we estimate a Cox proportional hazard model (Cox, 1972, 1975) for an individual plant *i* with covariates *x*:

$$h(t|x_i) = h_0(t) \cdot \exp(\boldsymbol{x}_i\boldsymbol{\beta})$$

where $h_0(t)$ is the baseline hazard function, indicating the hazard rate if all independent variables are equal to 1. In our estimation, we include the following independent variables: foreign-ownership, exporting, and importing dummies, log-transformed output, employment, female employment, and labour productivity (measured as output per worker), 'We also include province- and sector-dummies, number of plants in a *kabupaten* in year *t* and a restricted cubic spline function of plant age. In terms of inference, we clustered our standard error at the *kabupaten* level where the treatment is assigned to allow for arbitrary correlation of errors within the same regency.

4.3 Surviving plants

The empirical strategy used to evaluate the effect of flood events on surviving plants' performance has three features. First, we exploit within-plant variation of flood events. We consider plants that are observed for at least 6 consecutive years, and which have experienced flood events for the first time.[4] By focusing on initial exposure to flood events, we are controlling for potential differences in unobserved adaptation that can bias our estimates. This approach, however, dramatically reduces the number of observations that can be considered. Fortunately, we can observe numerous plant-level flood events to

[4] For those that existed prior to 1990, we do not know whether they had experienced flooding prior to 1990.

allow us to generalise the results with confidence.

Second, we use a DiD approach to compare the performance of those who had flooding with those that were never exposed to flood events during the comparison years. This approach eliminates the influence of all unobservable plant-specific variables that are constant or strongly persistent over time, but which are correlated with the probability of experiencing flood events, such as the ability to manage flood-related risks, amongst others. These differences in perceived ability to weather climate shocks may affect a plant's decision on where to locate its operation. For example, an importer or exporter may locate to flood-prone port cities to take advantage of trade-related benefits (e.g., lower transport costs to and from ports), '

Third, we develop a reasonable estimate of the counterfactual, that is, the change in the variables of interest that would have been observed had the plant not been exposed to a flood event. We have valid reasons and empirical evidence (please see succeeding discussion) to believe that some plants have higher probability of being exposed to floods than others due to significant differences in pre-flooding observable characteristics, which can bring bias to our estimated effect (Dehejia and Wahba, 2002), 'To address this issue, we employ a one-to-one propensity score matching (PSM), 'That is, for each treated plant that will have experienced its first flood event in the next period, we identify a control plant with similar characteristics using the procedure developed by Leuven and Sianesi (2012), 'We ensure that each treated plant is paired with a non-treated plant that is operating in the same sector and year, with the same type of ownership and import and export status, and has very similar trends in output (or revenues), employment, labour productivity, and female employment 3 years preceding the flood event. Matching within the industry-year cell ensures that we control for sector- and time-specific confounding factors that affect both treated and control plants. We use a matching procedure with replacement. To eliminate the potential spillover effect, we pick the control plants from any province except those where the treated plant belongs to and from those that did not experienced any flood event in that year.

After obtaining the matched pairs, we examine the effect of flood events on the plant-level variables of interest using a DiD approach. More specifically, we estimate the following equation on the matched sample on the 'prior to the flood' event and in one of the post-flooding years:

$$\ln(y_{it}) = \alpha_i + \gamma Post_t + \beta(Post_t * Flood_i) + \theta_{prov-trend} + \epsilon_{it}$$

where y_{it} is our dependent variable (e.g., plant i's output or employment in year t); $Flood_i$ is an indicator variable that turns to unity when plant i experienced a flood event and zero otherwise, α_i is plant-specific fixed effects, and $\theta_{prov-trend}$ is province-specific trends (province multiplied by linear time trend), and ϵ_it is the error, which we assume as independent and identically distributed random variables.

The estimating equation addresses several potential endogeneity issues. First, it exploits the panel structure of the dataset by including plant fixed effects α_i, which capture time-invariant plant-specific characteristics that may be correlated with the probability of flood events. These include, amongst others, differences across plants of varying sizes, different technologies, or different managerial capabilities, which may explain between-plant differences in exposure to flood events (e.g., location choices or planning), 'There are, however, numerous limitations to this methodology. First, there is potential for endogeneity. For instance, whilst the DiD framework compares plants that were affected by a flood in a given year with plants in the control group (Leuven and Sianesi, 2018), there remains likelihood of selection bias, as plants may strategically sort themselves and avoid locating in flood-prone areas. Thus, the method may be biased for observables, with behavioural differences between plants that have chosen to locate in high-flood-risk areas versus those in low-risk areas, as highlighted by Hu et al. (2019).

Second, we add province-specific trends $\theta_{prov-trend}$, which capture any long-term province-specific development that may influence disaster resilience in the area and in turn output of plants operating in the area. The method employs a framework similar to standard DiD used in the literature (Belasen and Polachek, 2009; Cole et al., 2008; Hu et al., 2019), assuming no selection bias associated with plants of certain characteristics pre-selecting themselves in locations with higher probability of flood events. The method also allows us to explore the persistence of and/or delay in the effect of the flood events on plant-level performance. This contrasts with previous studies (Hu et al., 2019), which are unable to accurately comment on persistence of effects because outcomes for unaffected plants in the absence of regional floods are unobserved.

We intend to lessen this endogeneity issue by combining DiD with a matching estimator. Inevitably, this will dramatically reduce the number of distinct observations in the control group, which can increase the estimator variance (Bai and Clark, 2019), 'Strict exogeneity may also be violated due to lagged effects, or employment in a flooded plant this year, affecting the outcome variables next year. Our method allows for the investigation of these effects. The problems of serial autocorrelation and spatial correlation of errors are addressed using clustered robust standard errors at the *kabupaten* level where the treatment is assigned. As per Coelli and Manasse (2014), heteroskedasticity is controlled for using within-cluster correlation at the plant and industry year level. There are also external validity concerns, as there may be general equilibrium effects or varying economic output dynamics in the Indonesian economy. Overall, randomisation is always preferred, but remains difficult to achieve given data limitations in the disaster literature (Cunningham, 2018), 'Thus, quasi-randomisation, as studied in this paper, is the next best option.

5. Results

5.1 Market entry

Table 2 presents the results of our *kabupaten*-level estimates of the determinants of plant entry. At the *kabupaten* level, we find no strong evidence to suggest that flooding deters or attracts plant births. In the first column, for example, the flood dummy has a coefficient that corresponds to an incidence ratio of 21.43, which implies that a *kabupaten* that experiences a flood event in time t would have plants births that are higher than those that were not exposed to the flooding by a magnitude of about 21. While this parameter estimate is large, it is not statistically significant. The same is true for plant exit at $t+1$, although plant exits are more adequately analysed in the succeeding subsection.

Table 2. The Determinants of Plant Exit and Births, 1990–2014 (Poisson estimation)

Variables	*Kabupaten*	
	Entry	Exit
Flood = 1; 0 else	21.43	7.960
	(1.25)	(0.61)
Flood*Time	–0.0108	–0.00397
	(–1.26)	(–0.61)
No. of plants	0.00119***	0.00264***
	(5.18)	(8.18)
Average age	–0.330***	–0.0609***
	(–15.67)	(–4.06)
No. of industries	–0.00823	–0.0129
	(–1.22)	(–1.74)
Kabupaten FE	Yes	Yes
Year FE	Yes	Yes
N	2,714	2,717
Observations	6643.3	19905.4
p-value	<0.0001	<0.0001

FE = fixed effects, N = number.

Note: The table presents incidence rate ratios from estimating a fixed effects Poisson regression. Each regression contains *kabupaten* and year effects. Standard errors are in parentheses and ***, **, and * denote coefficients that are significantly different from 0 at 99%, 95% and 90% confidence levels, respectively.

Source: Authors.

5.2 Market exit

A Cox-proportional hazard approach was used to determine market exit after flooding that occurred for the first time. A split sample was used to study impact on: (1) all plants, (2) domestic plants, (3) foreign-owned plants exporting but not importing, (4) foreign-owned plants importing but not exporting, (5) domestic plants importing and exporting, and (6) foreign-owned plants importing and exporting. Variables included output, employment, female employment, and labour productivity. Control variables (sage 1 and sage 2) are a cubic polynomial with two knots controlling the possible nonlinear trend across age of all plants. This can capture the probability of plants exiting being exponentially higher as plants become older.

Table 3 indicates that plants that have experienced flooding at first instance have a 55% higher likelihood of exiting the market, when compared to all other types of plants that did not experience flooding. The likelihood of exiting the market after experiencing flooding is highest amongst foreign-owned importing and exporting plants, which are twice as likely to exit the market. When studying other indicators such as output, it is observed that a one-unit increase in output would increase the hazard rate by 1.32% amongst all plants relative to other plants with a percentage higher output. The highest impact was faced by foreign-owned importing and exporting plants, a one-unit increase in output increased the hazard rate by 16.67% amongst this sample relative to other plants with a percentage higher output. In terms of employment, a one-unit increase in employment and female employment changed the hazard rate minimally amongst all plants relative to other plants with a percentage higher employment or female employment. For example, a one-unit increase in female employment in all plants had an increase in hazard rate by 6.38% relative to other plants with a percentage higher female employment. In terms of labour productivity, a one-unit increase in labour productivity would decrease the hazard rate by 12.34% amongst all plants relative to other plants with a percentage higher labour productivity.

Table 3. Determinants of Market Exit (Cox proportional hazards model)

Variables	All samples	Domestic plants only	Foreign owned and exporting only	Foreign owned and importing only	Domestic plant and with import and export	Foreign-owned plant and with import and export
1.flood	1.5598***	1.5416***	1.5287	1.8182**	1.7726***	2.0134***
	(0.1076)	(0.1195)	(0.4340)	(0.5466)	(0.3497)	(0.4384)
log_outputR	1.0132	1.0096	0.8785	1.1051	0.9876	1.1666**
	(0.0228)	(0.0261)	(0.1188)	(0.0927)	(0.0612)	(0.0738)
log_employ	0.6455***	0.6046***	0.7724	0.7599**	0.7104***	0.6122***
	(0.0286)	(0.0370)	(0.1656)	(0.0968)	(0.0734)	(0.0554)
log_femploy	1.0638***	1.0361*	1.1517	1.0766	1.2390***	1.2783***
	(0.0185)	(0.0215)	(0.1236)	(0.0948)	(0.0700)	(0.0632)
log_labprod	0.8766***	0.8966***	1.0182	0.8200***	0.9225	0.8757**
	(0.0201)	(0.0274)	(0.1345)	(0.0615)	(0.0571)	(0.0588)
sage1	1.1968***	1.2407***	1.1385***	1.2001***	1.1446***	1.2601***
	(0.0092)	(0.0114)	(0.0442)	(0.0445)	(0.0170)	(0.0597)
sage2	0.7464***	0.7000***	0.8693*	0.6860***	0.8367***	0.6879***
	(0.0109)	(0.0126)	(0.0645)	(0.0859)	(0.0222)	(0.0759)
n_psid	0.9994***	0.9995***	1.0000	0.9992**	1.0001	0.9995
	(0.0001)	(0.0002)	(0.0005)	(0.0003)	(0.0003)	(0.0005)
N	210,656	97,881	3,764	3,652	21,297	14,603
Pseudo R-sq.	0.03	0.04	0.08	0.06	0.05	0.06
Chi sq.	3,725.35	1,895.01	47,124.25	18,881.83	1,305.00	2,736.26

N = number.
Source: Authors.

5.3 Surviving plants – PSM combined with DiD

The validity of our combined PSM-DD estimation results relies heavily on the assumption that potential outcomes for the treated and control plants are orthogonal to treatment status, conditional on the observed characteristics that may be relevant to decisions that may affect the probability of being treated. For this reason, we need to show that both treated and control plants likely faced the same business and regulatory environments, sector-specific and country-wide shocks, and trends prior to experiencing flood events. This is partly established by matching within industry-year cell. Moreover, we also show that there is no statistically significant difference in the pre-flooding trends in the variables of interest for the matched 836 treated and 836 control plants, suggesting that our matching procedure has performed well, as seen in Table 4.

Table 4. Balancing Hypothesis

	N_1	N_2	Control	Treated	Difference	p-value
logoutputRtrendlag	836	836	–0.02	0.01	–0.04	0.32
logemploytrendlag	836	836	0.01	–0.00	0.02	0.33
loglabprodtrendlag	836	836	–0.09	–0.04	–0.05	0.28
logfemploytrendlag	836	836	0.04	0.01	0.03	0.32
logval_addedtrendlag	836	836	0.34	0.37	–0.03	0.46
foreign_dummylag1	836	836	0.00	0.00	0.00	1.00
foreign_dummylag2	836	836	0.00	0.00	0.00	1.00
foreign_dummylag3	836	836	0.00	0.00	0.00	1.00
export_dummylag1	808	808	0.03	0.03	0.00	1.00
export_dummylag2	833	833	0.07	0.07	0.00	1.00
export_dummylag3	825	825	0.08	0.08	0.00	1.00
import_dummylag1	836	836	0.02	0.02	0.00	1.00
import_dummylag2	836	836	0.02	0.02	0.00	1.00
import_dummylag3	836	836	0.03	0.03	0.00	1.00
N	1,672					

N = number.
Note: logoutputRtrendlag = difference in log-transformed output between *t-3* and *t-1*, *t* being the year the flood event was experienced. Logemploytrendlag, loglabprodtrendlag, logfemploytrendlag, logval_addedtrendlag are analogous variables for employment, labour productivity (output per worker), female employment and value-added. foreign_dummylag1- foreign_dummylag3 are lagged foreign-ownership dummy in *t-1* to *t-3*. export_dummylag1- import_dummylag3 are analogous variables applied to import and export status.
Source: Authors.

Results of the combined PSM-DD estimation are illustrated in Figure 2. Results suggest that when we compare those plants that have experienced flooding at first instance with a carefully selected comparable plant, we do not see any significant difference in employment, whether overall or female, at the time the flood was experienced. This pattern holds for periods succeeding the plant event, i.e. from the first to third year after the flood event.

In contrast, we see a delayed but statistically significant decline in output and output per worker 2 years after the flood event. Results show that plants experiencing a flood event for the first time are observed to have a decline of about 32% in output per worker 2 years after the flood event, relative to its pre-flood level. This reduction is reduced to 15% after 3 years and is statistically insignificant. Moreover, this result dissipates when we remove years that are potentially subject to anomalies. We discuss this issue in the succeeding subsection.

Figure 2. Estimated Effect, Combined PSM with DiD

DiD = difference-in-difference, PSM = propensity score matching.

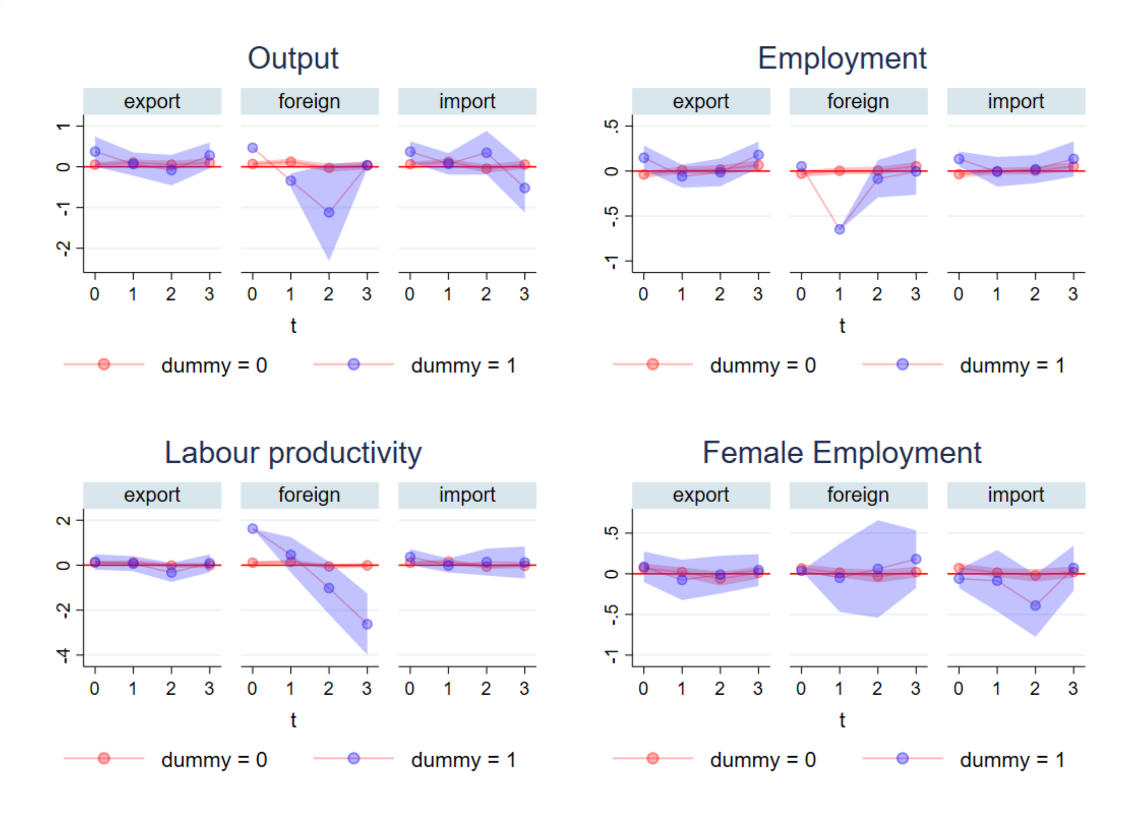
Note: The figure above presents the estimated effect of experiencing flood for the first time on the matched sample, following the procedure discussed in the empirical strategy. The range plot pertains to the 95% confidence interval. *t* refers to the year the flood event occurred, implying that the value of 1 means the year after the flood event was experienced. Detailed regression results are found in the Appendices.

Source: Authors.

We also looked at possible heterogeneity in flood-induced adjustments across different ownership types and export–import statuses, implying a difference-in-difference-in-differences effect. The middle pane of the top left panel of Figure 3, for example, illustrates the marginal effect of experiencing a flood event at first instance on a foreign-owned firm's output relative to those domestic firms that had the same flood experience. Results show no significant difference in output and employment for importers and exporters relative to their local counterparts after experiencing a flood event. This is also true for labour productivity (output per worker) and female employment.

In contrast, we see a persistent downward trend in output per worker for foreign-owned plants in the aftermath of a flood event, relative to plants that have the same flood experience but remained domestically owned. We discuss the potential reason and implications of this finding in more detail in the Discussion section.

Figure 3. Estimated Heterogeneity of Effects, PSM Combined with DiD



DiD = difference-in-difference, PSM = propensity score matching.

Note: The figure above presents the estimated effect of experiencing flooding for the first time on the matched sample, conditional on whether the plant is (1) exporter ('export'); (2) foreign-owned ('foreign') or (3) importer ('import'), following the procedure discussed in the empirical strategy. The range plot pertains to the 95% confidence interval.

Source: Authors.

5.4 Robustness checks

Indonesian data do not come without imperfections, with previous studies noting anomalous years that can influence results. For example, since the dataset crosses the 1997–98 Asian Financial Crisis, data were removed, as the period has some problems regarding accuracy. There were also issues in relation to Indonesian political reform starting in 1998 and the documented low representativeness in 2004. To address this issue, we dropped matched samples with flood-years occurring before 2005. This significantly reduces the total number of observations for those surviving plants to 390 matched samples, down from 836 in the initial sample. The reduction also forced us to perform meaningful empirical analysis at a more disaggregated level (i.e. foreign-owned plants, importers, and exporters) due to a very limited matched sample. Results are fairly the same with our initial analysis mainly in terms of having no significant effect of flood cases on surviving plants' economic performance.[5]

For our survival analysis, we dropped years earlier than 2005. This reduces not only the number of observations but also the number of plants exiting the sector, considering that an average firm would have 16 years of observations in the dataset. Notwithstanding, we repeated the survival analysis and examined whether we can find significant effects of flood events on plants' survival. Even with the aforementioned caveats, results show a remarkable increase in the probability of foreign-owned plants involved in both imports and exports exiting the sector. Other groups seem to exhibit statistically significant increases in their survival probabilities with the truncated dataset, albeit slight changes in the magnitude of the change. Only those plants that are foreign-owned and importing only have lost their statistical significance in terms of the effect of flood events on market entry.[6]

In terms of entry, results remain the same as those of the previous analysis. In other words, we do not find any statistically significant effect of flood events on the entry rate of plants.

[5] For the plots and regression results, see Appendices.

[6] Detailed results are in the Appendices.

6. Discussion

6.1 Market entry and exit

Overall, no significant results were found for market entry. In terms of market exit, while the probability of exits amongst all plants after the first flooding instance is higher, results show that there are some distributional concerns with regards to foreign-owned exporting and importing plants. Disproportional exits amongst foreign-owned importing and exporting plants may be due to the ability to move assets elsewhere both domestically (to another *kabupaten*) or internationally. Conversely, domestic plants may be more restricted in terms of movement of assets. Another aspect to explore in future research is the relationship between plant exits and flood intensity, which may influence the factors associated with plant movement (discussed in the Areas of further research), ‘

The exit of foreign-owned plants can have negative implications for long-term FDI and technological transfer in the manufacturing sector. This is policy-pertinent, given the crucial role of FDI in the context of Indonesia’s manufacturing sector (Kuncoro, 2012), ‘Disaster impacts can therefore lead to lower long-term development pathways (Albala-Bertrand, 1993; Stephane Hallegatte, 2017), ‘These results are policy pertinent for other AMSs, where limited reconstruction capacity (Benson and Clay, 2004) can prolong recovery and reduce investment in ex-ante disaster preparedness.

6.2 Surviving plants

Amongst surviving plants, PSM DiD results show that there is no significant difference amongst comparable plants in terms of performance indicators such as output, employment, and labour productivity. Except in the case of foreign-owned plants, in most cases, it takes approximately 1 to 2 years for plants to recover following a flooding event, in comparison to comparable non-flooded plants. For example, foreign-owned surviving plants were most likely to adjust employment post-flooding. The impact on employment has significant implications for wages and long-term economic growth, given that foreign-owned plants have typically higher wages (Verico and Pangestu, 2020), ‘Such industry-wide vulnerability, combined with dysfunctional labour markets, impedes macroeconomic performance. Concerningly, this affects the poorest in society if impacts are disproportionately borne by female or production workers.

Impacts on female employment post-flooding have not been investigated in Indonesia previously. While the results for surviving plants do not indicate a disproportionate impact on female employment, it may be that the effect on female employment is connected to plant exits. Do exiting firms employ significantly higher share of women? And what happens to displaced workers when a plant exits the marker due to climate-related disaster shocks? These points are salient given the poverty trajectories in Southeast Asia post-COVID-19 (Sumner et al., 2020) and should be explored further.

7. Policy Implications

This paper provides three main lessons for firms, investors, and national policymakers:

- **Improved quantification of disaster-related losses:** Findings reflect the true economic impacts of natural hazard-related disasters. Understanding impacts at the manufacturing plant level is essential, as they provide critical inputs for other sectors, causing ripple effects in the rest of the economy. Establishing the extent of damage and heterogeneity of impacts can assist the Indonesian government in providing adequate and targeted disaster aid. Moreover, insights into plant-level physical risk can aid foreign investors in decision-making, given supply chain repercussions.
- **Early investment in disaster resilience:** Results can incentivise firms to undertake appropriate adaptation measures such as import substitution, technology adoption or insurance uptake. Reducing exposure through adaptation can significantly limit losses in Southeast Asia, where socio-economic development is a climate risk driver. Being aware of heterogeneity of losses can also help governments support vulnerable firms in the manufacturing sector. This includes ex-ante investments such as parametric insurance or relocation (e.g. asset buy-out policies) based on plant-level exposure. Similarly, long-term Disaster Risk Reduction investments are recommended, even when there is no disaster

damage in view of the resilience co-benefits beyond avoided losses, such as increased economic activity, improved competitiveness, supply chain stability, and enhanced company credit ratings.

- **Mitigating impacts of reduced FDI on long-run growth:** Results suggest foreign firms may be disproportionately impacted by flooding. This poses the risk of macrolevel poverty traps given the key role of FDI in Indonesia as a driver of output, employment, and technological progress. Consequently, the Indonesian government can strengthen Disaster Risk Reduction investments, as per the above, and factor in natural hazard-related impacts when designing trade policies to ensure ongoing FDI.

8. Conclusion

This paper investigated the market entry, survival, and exit of firms in the aftermath of natural hazard-related disasters. Using a case study of Indonesian manufacturing plants, it addressed literature gaps by establishing a link between flooding, global market activities, and impacts on sustainable development objectives. The paper combined plant-level data from the Indonesian Manufacturing Survey and localised disaster data from the EM-DAT database for 1990–2015 to study impacts at the *kabupaten* level using: Poisson regression (entry), Cox-proportional hazard approach (exit), and PSM combined with DiD (surviving firms).

Flooding was not found to have a significant impact on plant entry. The probability of exits amongst all plants after the first flooding instance was higher, with disproportional exits amongst foreign-owned importing and exporting plants. Finally, for surviving plants, no significant difference was found amongst comparable plants in terms of output, employment, and female employment. However, plants that are connected and foreign-owned experienced a persistent decline in output per worker relative to their domestic counterparts in the aftermath of a flooding event.

The impact on employment and foreign-owned firms has significant implications for wages and long-term economic growth. This can jeopardise development objectives if impacts are disproportionately borne by female or production workers. While results for surviving firms suggest no strong evidence of detrimental effects on female employment, safeguards should be established to prevent risk of persistent underdevelopment.

Importantly, this paper strengthens the argument for increasing investment in disaster resilience. By looking at resilience co-benefits to include economic development and competitiveness, which are beyond simply avoided losses, a strong economic case can be made for increased adaptation spending. Against rising disaster losses and the consequent firm-level impacts and development concerns highlighted in this paper, underspending in ex-ante measures is certain to exacerbate challenges posed by natural-hazard-related disasters.

9. Areas of Further Research

To further confirm the validity of the result for plant market entry, exit, and survival, we suggest using flood intensity and frequency as a variable to control for the magnitude of the shock experienced. Adding flood intensity and frequency will enable us to study both extensive and intensive margins of flooding. This may provide more robust results concerning impacts on female employment, particularly in years of major flooding events such as 2007 and 2017. Additionally, there may be heterogeneity in terms of impacts, with the total number of consecutive flood experiences influencing a plant's decision to exit or relocate.

Next, the distributional impacts of plant exits can be further investigated, with an emphasis on female and production workers. While gendered impacts of economic shocks, like the 1997 Asian Financial Crisis have been studied, the mechanisms at play in the aftermath of a natural disaster may be different. Findings will be policy-pertinent, given that growth in manufacturing employment is positively correlated with higher school enrolment and female labour force participation.

References

Albala-Bertrand, J.M. (1993), ‘Natural Disaster Situations and Growth: A Macroeconomic Model for Sudden Disaster Impacts’, *World Development*, 21(9), pp.1417–34. https://doi.org/10.1016/0305-750x(93)90122-p. (Accessed on 10 August 2021).

Altay, N. and A. Ramirez (2010), ‘Impact of Disasters on Firms in Different Sectors: Implications for Supply Chains’, *Journal of Supply Chain Management*, 46(4), pp.59–80.

Ambrosini, V., C. Bowman, and N. Collier (2009), ‘Dynamic Capabilities: An Exploration of How Firms Renew Their Resource Base’, *British Journal of Management*, 20, pp.S9–S24.

Anuchitworawong, C. and K.Thampanishvong, (2015), ‘Determinants of Foreign Direct Investment in Thailand: Does Natural Disaster Matter?’, *International Journal of Disaster Risk Reduction*, 14, pp.312–21. https://doi.org/10.1016/j.ijdrr.2014.09.001. (Accessed on 10 August 2021).

Asian Development Bank (ADB), ‘(2016), *Republic of Indonesia: Flood Management in Selected River Basins Sector Project*, https://www.adb.org/projects/documents/ino-flood-management-selected-river-basins-sector-project-rrp. (Accessed on 10 August 2021).

Asian Development Bank (ADB) (2020), *Environment Safeguards*, https://www.adb.org/site/safeguards/environment. (Accessed on 10 August 2021).

Atela, J., K.E. Gannon, and F. Crick (2018), ‘Climate Change Adaptation Among Female-Led Micro, Small, and Medium Enterprises in Semiarid Areas: A Case Study from Kenya’, in W. Leal Filho (ed.) *Handbook of Climate Change Resilience.* Springer International Publishing, pp.1–18.

Bai, H. and M.H. Clark (2019), *Propensity Score Methods and Applications*, https://doi.org/10.4135/9781071814253. (Accessed on 10 August 2021).

Badan Pusat Statistik (BPS) (2017), ‘Disaster Statistics in BPS Statistics Indonesia’, https://psa.gov.ph/system/files/session%203-3_iriana.pdf. (Accessed on 10 August 2021).

Barrot, J.N. and J. Sauvagnat (2016), ‘Input Specificity and the Propagation of Idiosyncratic Shocks in Production Networks’, *Quarterly Journal of Economics*, 131(3), pp.1543–92. https://doi.org/10.1093/qje/qjw018. (Accessed on 10 August 2021).

Barthel, F. and E. Neumayer (2012), ‘A Trend Analysis of Normalized Insured Damage from Natural Disasters’, *Climatic Change*, 113(2), pp.215–37. https://doi.org/10.1007/s10584-011-0331-2. (Accessed on 10 August 2021).

Basker, E. and J. Miranda (2018), ‘Taken By Storm: Business Financing and Survival in the Aftermath of Hurricane Katrina’, *Journal of Economic Geography*, 18(6), pp.1285–313._

Battisti, M. and D. Deakins (2017), ‘The Relationship Between Dynamic Capabilities, the Firm's Resource Base and Performance in a Post-Disaster Environment', *International Small Business Journal*, 35(1), pp.78–98. https://doi.org/10.1177/0266242615611471. (Accessed on 10 August 2021).

Belasen, A.R. and S. W. Polachek (2009), 'How Disasters Affect Local Labour Markets: The Effects of Hurricanes in Florida', *Journal of Human Resources*, 44(1), pp.251–76. https://doi.org/10.3368/jhr.44.1.25. (Accessed on 10 August 2021).

Benson, C. and E.Clay (2004), *Understanding the Economic and Financial Impacts of Natural Disasters*. Washington, DC: The World Bank.

Boudreaux, C.J., M.P. Escaleras, and M. Skidmore (2019), 'Natural Disasters and Entrepreneurship Activity', *Economics Letters*, 182, pp.82–85. https://doi.org/10.1016/j.econlet.2019.06.010. (Accessed on 10 August 2021).

Brandt, L., J. Van Biesebroeck, and Y. Zhang (2012), 'Creative Accounting Or Creative Destruction? Firm-Level Productivity Growth in Chinese Manufacturing', *Journal of Development Economics*, 97(2), pp.339–51. https://doi.org/10.1016/j.jdeveco.2011.02.002. (Accessed on 10 August 2021).

Brucal, A., B. Javorcik, and I. Love (2019), 'Good for the Environment, Good for Business: Foreign Acquisitions and Energy Intensity', *Journal of International Economics*, 121, 103247. https://doi.org/10.1016/j.jinteco.2019.07.002. (Accessed on 10 August 2021).

Budiyono, Y., J.C.J.H. Aerts, D. Tollenaar, and P.J. Ward (2016), 'River Flood Risk in Jakarta Under Scenarios of Future Change', *Natural Hazards and Earth System Sciences*, 16(3), pp.757–74.

Cao, Y., C. Leon-Himmelstine, and E. Lovell (2019), 'Strengthening Women-Focused Investments in Climate and Disaster Resilience', *ODI and ADB*.

Chongvilaivan, A. (2012), *Thailand's 2011 Flooding: Its Impact on Direct Exports and Global Supply Chains Asia-Pacific Research and Training Network on Trade*. Bangkok: Asia-Pacific Research and Training Network on Trade (Artnet), www.artnetontrade.org. (Accessed on 10 August 2021).

Coelli, F. and P. Manasse (2014), *The Impact of Floods on Firms' Performance* (No. 946; quaderni), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2440712. (Accessed on 10 August 2021).

Cole, M.A., R.J.R. Elliott, T. Okubo, and E. Strobl (2019), 'Natural Disasters and Spatial Heterogeneity in Damages: The Birth, Life and Death of Manufacturing Plants. *Journal of Economic Geography*, 19(2), pp.373–408. (Accessed on 10 August 2021).

Cole, M.A., R.J.R. Elliott, and E. Strobl (2008), 'The Environmental Performance of Firms: The Role of Foreign Ownership, Training, and Experience. *Ecological Economics*, 65(3), pp.538–46. https://doi.org/10.1016/j.ecolecon.2007.07.025. (Accessed on 10 August 2021).

Cole, M.A., R.J.R. Elliott, and L. Zhang (2017), 'Foreign Direct Investment and the Environment', *Annual Review of Environment and Resources*, 42(1), pp.465–87. https://doi.org/10.1146/annurev-environ-102016-060916. (Accessed on 10

August 2021).

Craioveanu, M. and D. Terrell (2016), *The Impact of Storms on Firm Survival: a Bayesian Spatial Econometric Model for Firm Survival* (Vol. 37, pp.81–118), Emerald Publishing Ltd. https://econpapers.repec.org/repec:eme:aecozz:s0731-905320160000037010. (Accessed on 10 August 2021).

Crespo Cuaresma, J., J. Hlouskova, and M. Obersteiner (2008), 'Natural Disasters As Creative Destruction? Evidence from Developing Countries. *Economic Inquiry*, 46(2), pp.214–26. https://doi.org/10.1111/j.1465-7295.2007.00063. (Accessed on 10 August 2021).

Cunningham, S. (2018), *Causal Inference: The Mixtape*. https://www.degruyter.com/document/doi/10.12987/9780300255881/html. (Accessed on 10 August 2021).

Dacy, D.C. and H. Kunreuther (1969), *Economics of Natural Disasters: Implications for Federal Policy*.

Davis, I. and D. Alexander (2015), *Recovery from Disaster*. Routledge.

Dormady, N., A. Roa-Henriquez, and A. Rose (2019), 'Economic Resilience of the Firm: a Production Theory Approach', *International Journal of Production Economics*, 208, pp.446–60. https://doi.org/10.1016/j.ijpe.2018.07.017. (Accessed on 10 August 2021).

Doytch, N. and Y.L. Klein (2018), 'The Impact of Natural Disasters on Energy Consumption: An Analysis of Renewable and Nonrenewable Energy Demand in the Residential and Industrial Sectors', *Environmental Progress and Sustainable Energy*, 37(1), pp.37–45. https://doi.org/10.1002/ep.12640. (Accessed on 10 August 2021).

Echendu, A.J. (2020), 'The Impact of Flooding on Nigeria's Sustainable Development Goals (SDGS)', *Ecosystem Health and Sustainability*, 6(1), https://doi.org/10.1080/20964129.2020.1791735. (Accessed on 10 August 2021).

Elliott, R.J.R., Y. Liu, E. Strobl, and M. Tong (2019), 'Estimating the Direct and Indirect Impact of Typhoons on Plant Performance: Evidence from Chinese Manufacturers', *Journal of Environmental Economics and Management*, 98, 102252. https://doi.org/10.1016/j.jeem.2019.102252. (Accessed on 10 August 2021).

FAO. (2016), *Resilience Analysis in Isiolo, Marsabit and Meru: Kenya* 2016. http://www.fao.org/resilience/resources/resources-detail/en/c/1026367/. (Accessed on 10 August 2021).

Gassebner, M., A. Keck, and R. Teh (2010), 'Shaken, Not Stirred: The Impact of Disasters on International Trade', *Review of International Economics*, 18(2), pp.351–68. https://doi.org/10.1111/j.1467-9396.2010.00868. (Accessed on 10 August 2021).

Global Facility for Disaster Reduction and Recovery. (2019), *Indonesia*. https://www.gfdrr.org/en/indonesia. (Accessed on 10 August 2021).

Hadri, H.E.L., D. Mirza, and I. Rabaud (2017), 'Natural Disasters and Countries' Exports: New Insights from a New (and An Old) Database', *LEO Working Papers / DR*

LEO. https://ideas.repec.org/p/leo/wpaper/2600.html. (Accessed on 10 August 2021).

Hallegatte, S. (2017), 'A Normative Exploration of the Link Between Development, Economic Growth, and Natural Risk', *Economics of Disasters and Climate Change*, 1(1), pp.5–31. https://doi.org/10.1007/S41885-017-0006-1. (Accessed on 10 August 2021).

Hallegatte, S. (2008), 'An Adaptive Regional Input-Output Model and Its Application To the Assessment of the Economic Cost of Katrina', *Risk Analysis: An International Journal*, 28(3), pp.779–99.

Hallegatte, S., M. Bangalore, and M-A. Jouanjean (2016), 'Avoided Losses and the Development Dividend of Resilience', In Surminski and Tanner (eds.) *Realising the 'Triple Dividend of Resilience',* Berlin: Springer. pp.31–54.

Hallegatte, S., J. Rentschler, and J. Rozenberg (2019), *Lifelines: The Resilient Infrastructure Opportunity*. Washington, DC: The World Bank.

Hallward-Driemeier, M., B. Rijkers, and A.Waxman (2017), 'Do Employers' Responses to Crises Impact Men and Women Differently? Firm-Level Evidence from Indonesia', *Review of Development Economics*, 21(4), pp.1018–56. https://doi.org/10.1111/rode.12230. (Accessed on 10 August 2021).

Hamaguchi, N. (2013), *Impact of the Great East Japan Earthquake on Local Industries: Synthesis and Analysis from a Survey (Japanese)* (Policy Discussion Papers [in Japanese]), Research Institute of Economy, Trade and Industry (RIETI), https://econpapers.repec.org/repec:eti:rpdpjp:1300. (Accessed on 10 August 2021).

Hanger, S., J. Linnerooth-Bayer, S. Surminski, C. Nenciu-Posner, A. Lorant, R.Ionescu, and A.Patt (2018), 'Insurance, Public Assistance, and Household Flood Risk Reduction: A Comparative Study of Austria, England, and Romania', *Risk Analysis*, 38(4), pp.680–93.

Henriet, F., S. Hallegatte, and L. Tabourier (2012), 'Firm-Network Characteristics and Economic Robustness to Natural Disasters', *Journal of Economic Dynamics and Control*, 36(1), pp.150–67.

Hiles, A. (2010), *The Definitive Handbook of Business Continuity Management*. Chichester: John Wiley and Sons.

Holling, C.S. (1973), 'Resilience and Stability of Ecological Systems', *Annual Review of Ecology and Systematics*, 4(1), pp.1–23.

Hu, X., R. Pant, J.W. Hall, S.Surminski, and J. Huang (2019), 'Multi-Scale Assessment of the Economic Impacts of Flooding: Evidence from Firm to Macro-Level Analysis in the Chinese Manufacturing Sector', *Sustainability*, 11(7), 1933. https://doi.org/10.3390/su11071933. (Accessed on 10 August 2021).

IDB. (2020), *Private Markets for Climate Resilience: Global Report*. https://publications.iadb.org/en/private-markets-for-climate-resilience-global-report. (Accessed on 10 August 2021).

IMF. (2020), '*Chapter 5: Climate Change: Physical Risk and Equity Prices*. Global

Financial Stability Report (April 2020), https://www.imf.org/en/publications/gfsr/issues/2020/04/14/global-financial-stability-report-april-2020. (Accessed on 10 August 2021).

Ishiwata, H., H.Wada, K. Suzuki, M. Ikeda, and N.Tada, (2020), *A Quantitative Analysis of Disaster Risk Reduction Investment Effects for Sustainable Development: Indonesia Case Study*. https://www.think-asia.org/handle/11540/12201. (Accessed on 10 August 2021).

Ivanov, D. and A. Dolgui (2020), 'Viability of Intertwined Supply Networks: Extending the Supply Chain Resilience Angles towards Survivability. A Position Paper Motivated by the COVID-19 Outbreak', *International Journal of Production Research*, 58(10), pp.2904–15.

Kato, H. and T. Okubo (2018), 'The Impact of a Natural Disaster on Foreign Direct Investment and Vertical Linkages', *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2983835. (Accessed on 10 August 2021).

Kilian, L. and C. Park (2009), 'The Impact of Oil Price Shocks on the U.S. Stock Market', *International Economic Review*, 50(4), pp.1267–87. https://doi.org/10.1111/j.1468-2354.2009.00568. (Accessed on 10 August 2021).

Kode Pos Indonesia. (2020). https://kodepos.nomor.net/_kodepos.php?_i=provinsi-kodepos. (Accessed on 10 August 2021).

Koks, E., R. Pant, S. Thacker, and J.W. Hall (2019), 'Understanding Business Disruption and Economic Losses Due To Electricity Failures and Flooding', *International Journal of Disaster Risk Science*, 10(4), pp.421–38. https://doi.org/10.1007/s13753-019-00236-y. (Accessed on 10 August 2021).

Kuncoro, A. (2012), *Globalization and Innovation in Indonesia: Evidence from Micro-Data on Medium and Large Manufacturing Establishments* (ERIA Discussion Paper Series), https://www.eria.org/eria-dp-2012-09.pdf. (Accessed on 10 August 2021).

Leiter, A.M., H. Oberhofer, and P.A. Raschky (2009), 'Creative Disasters? Flooding Effects on Capital, Labour and Productivity Within European Firms', *Environmental and Resource Economics*, 43(3), pp.333–50.

Leuven, E. and B. Sianesi (2018), *PSMATCH2: Stata Module To Perform Full Mahalanobis and Propensity Score Matching, Common Support Graphing, and Covariate Imbalance Testing*. https://econpapers.repec.org/repec:boc:bocode:s432001. (Accessed on 10 August 2021).

Liu, Z., J. Xu, and B.T. Han (2013), 'Small-and Medium-Sized Enterprise Post-Disaster Reconstruction Management Patterns and Application', *Natural Hazards*, 68(2), pp.809–35.

Loayza, N.V., E. Olaberría, J. Rigolini, and L. Christiaensen (2012), 'Natural Disasters and Growth: Going Beyond the Averages', *World Development*, 40(7), pp.1317–36. https://doi.org/10.1016/j.worlddev.2012.03.002. (Accessed on 10 August 2021).

Mandel, A., T. Tiggeloven, D. Lincke, E.Koks, P. J. Ward, and J. Hinkel, (2020), 'Risks on Global Financial Stability Induced by Climate Change', *PNAS*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3626936. (Accessed on 10 August 2021).

McGrath, R.G. (2013), *The End of Competitive Advantage: How To Keep Your Strategy Moving As Fast As Your Business*. Cambridge, MA: Harvard Business Review Press.

McKinsey Global Institute. (2020), *Climate Risk and Response: Physical Hazards and Socioeconomic Impacts*. https://www.mckinsey.com/business-functions/sustainability/our-insights/climate-risk-and-response-physical-hazards-and-socioeconomic-impacts. (Accessed on 10 August 2021).

Miyakawa, D., K. Hosono, T. Uchino, A. Ono, H. Uchida, and I. Uesugi (2016), *Financial Shocks and Firm Exports: A Natural Experiment Approach With a Massive Earthquake* (No. 50; Real Estate Markets, Financial Crisis, and Economic Growth : An Integrated Economic Approach),

Neise, T. and J.R. Diez (2019), 'Adapt, Move Or Surrender? Manufacturing Firms' Routines and Dynamic Capabilities on Flood Risk Reduction in Coastal Cities of Indonesia', *International Journal of Disaster Risk Reduction*, 33, pp.332–42.

Oh, C.H. and R.Reuveny (2010), 'Climatic Natural Disasters, Political Risk, and International Trade', *Global Environmental Change*, 20(2), pp.243–54. https://doi.org/10.1016/j.gloenvcha.2009.11.005. (Accessed on 10 August 2021).

Pathak, S. and M.M. Ahmad (2016), 'Flood Recovery Capacities of the Manufacturing Smes from Floods: A Case Study in Pathumthani Province, Thailand', *International Journal of Disaster Risk Reduction*, 18, pp.197–205. https://doi.org/10.1016/j.ijdrr.2016.07.001. (Accessed on 10 August 2021).

Pauw, P. and A. Pegels (2013), 'Private Sector Engagement in Climate Change Adaptation in Least Developed Countries: An Exploration', *Climate and Development*, 5(4), pp.257–67. https://doi.org/10.1080/17565529.2013.826130. (Accessed on 10 August 2021).

Preventionweb. (2015), *Direct and Indirect Losses*. https://www.preventionweb.net/risk/direct-indirect-losses. (Accessed on 10 August 2021).

Raddatz, C. (2009), 'The Wrath of God Macroeconomic Costs of Natural Disasters', *World Bank Working Paper*, 24(September), pp.65–75. https://doi.org/10.1596/1813-9450-5039. (Accessed on 10 August 2021).

Rodríguez-Pose, A., V. Tselios, D. Winkler, and T.Farole (2013), 'Geography and the Determinants of Firm Exports in Indonesia', *World Development*, 44, pp.225–40. https://doi.org/10.1016/j.worlddev.2012.12.002. (Accessed on 10 August 2021).

Rose, A. (2009), 'A Framework for Analyzing the Total Economic Impacts of Terrorist Attacks and Natural Disasters', *Journal of Homeland Security and Emergency Management*, 6(1). https://doi.org/10.2202/1547-7355.1399. (Accessed on 10 August 2021).

Rose, A. (2016), 'Capturing the Co-benefits of Disaster Risk Management in the Private Sector. In Surminski and Tanner (eds.) *Realising the 'Triple Dividend of Resilience',* Berlin: Springer, pp.105–27.

Scor SE. (2013), *Supply Chain and Contingent Business Interruption (CBI): a Perspective on Property and Casualty*. https://www.imia.com/wp-content/uploads/2013/12/ep49_2013-scor_focus_on_cbi-_seminar-_2013.pdf. (Accessed on 10 August 2021).

Skidmore, M. and H. Toya (2002), 'Do Natural Disasters Promote Long-Run Growth?', *Economic Inquiry*, 40(4), pp.664–87. https://doi.org/10.1093/ei/40.4.664. (Accessed on 10 August 2021).

Strobl, E. (2019), *The Impact of Typhoons on Economic Activity in the Philippines: Evidence from Nightlight Intensity*. Asian Development Bank Economics Working Paper Series, (589), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3590202. (Accessed on 10 August 2021).

Sumner, A., C. Hoy, and E. Ortiz-Juarez (2020), 'Estimates of the Impact of COVID-19 on Global Poverty', *UNU-WIDER, April*, pp.800–09.

Surminski, S. and Tanner, T. (2016), '*Realising the "Triple Dividend of Resilience"',* Berlin: Springer. (pp.31–54).

Tembata, K. and K. Takeuchi (2019), 'Floods and Exports: An Empirical Study on Natural Disaster Shocks in Southeast Asia', *Economics of Disasters and Climate Change*, 3(1), pp.39–60. https://doi.org/10.1007/s41885-018-0033-6. (Accessed on 10 August 2021).

Thorbecke, W. (2016), *Increasing the Resilience of Asian Supply Chains To Natural Disasters: The Role of the Financial Sector* (ERIA Discussion Paper Series),

Van Veen-Groot, D.B., and P. Nijkamp, (1999), 'Globalisation, Transport and the Environment: New Perspectives for Ecological Economics', *Ecological Economics,* 31(3), pp.331–46.

Verico, K. and M.E. Pangestu (2020), *The Economic Impact of Globalisation in Indonesia* (No. 338; ERIA Discussion Paper Series), 'https://www.eria.org/uploads/media/discussion-papers/the-economic-impact-of-globalisation-in-indonesia.pdf. (Accessed on 10 August 2021).

Wagner, J. (2013), 'Exports, Imports and Firm Survival: First Evidence for Manufacturing Enterprises in Germany', *Review of World Economics*, 149(1), pp.113–30. https://doi.org/10.1007/s10290-012-0141-2. (Accessed on 10 August 2021).

Winsemius, H.C., et al. (2016), 'Global Drivers of Future River Flood Risk', *Nature Climate Change*, 6(4), pp.381–85.

Xie, W., N. Li, J. Wu, and X.Hao (2015), 'Disaster Risk Decision: a Dynamic Computable General Equilibrium Analysis of Regional Mitigation Investment. *Human and Ecological Risk Assessment*, 21(1), pp.81–99.

Yumarni, T. and D. Amaratunga (2015), *Resource Capability for Local Government in*

Mainstreaming Gender Into Disaster Risk Reduction: Evidence from Indonesia.

Zhang, Y., M.K. Lindell, and C.S. Prater (2009), 'Vulnerability of Community Businesses to Environmental Disasters', *Disasters*, 33(1), pp.38–57.

Appendices

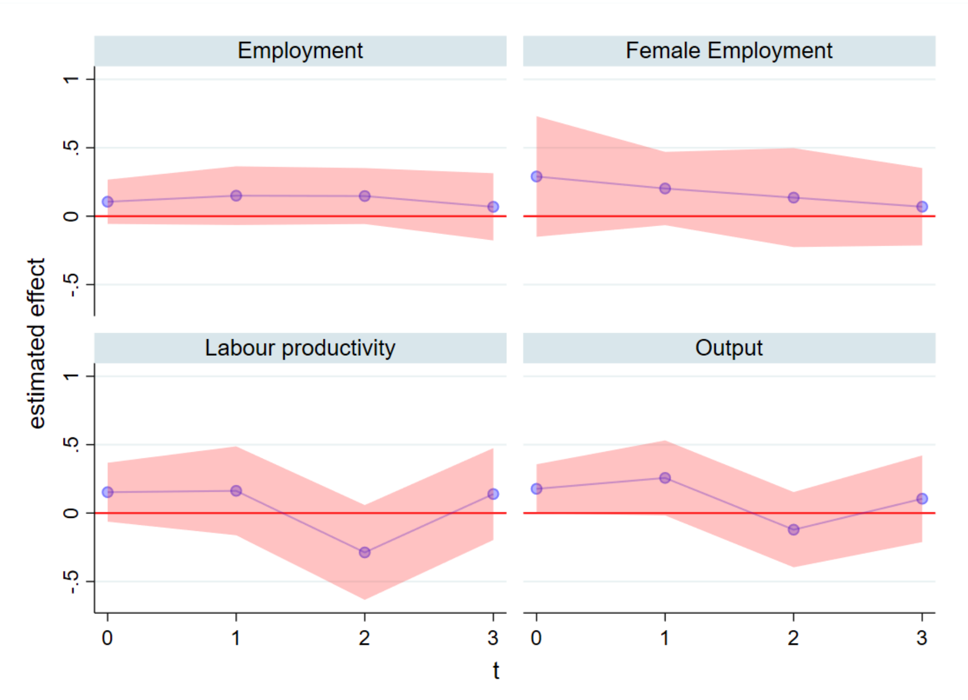
Table A.1. Estimated Effect on Flood Events on Surviving Plants, Combined PSM with DiD, complete sample.

	Log (employment)				Log (female employment)			
Treatment*Post	–0.144	-0.0299	–0.0521	-0.00941	-0.0293	0.0273	-0.0843	0.0294
	(–1.57)	(–0.70)	(–1.13)	(–0.18)	(–0.41)	(0.65)	(–1.18)	(0.64)
N	3,344	3,344	3,344	3,344	3,318	3,302	3,284	3,274
	Log (output/worker)				Log (output)			
Treatment*Post	0.171	0.0455	-0.232**	–0.0711	-0.0119	-0.0152	-0.317*	–0.151
	(1.68)	(0.49)	(–2.69)	(–0.76)	(–0.26)	(–0.22)	(–2.42)	(–1.02)
N	3,344	3,344	3,344	3,344	3,344	3,344	3,344	3,344

DiD = difference-in-difference, N= number, PSM = propensity score matching.

Source: Authors.

Figure A.1. Estimated Effect on Flood Events on Surviving Plants, Combined PSM with DiD, Truncated Sample (2005–15)



DiD = difference-in-difference, PSM = propensity score matching.

Source: Authors.

Table A.2. Estimated Effect on Flood Events on Surviving Plants, Combined PSM with DiD, truncated sample

	Log (employment)				Log (female employment)			
Treatment*Post	0.108	0.150	0.147	0.0685	0.289	0.202	0.136	0.0693
	(1.28)	(1.39)	(1.43)	(0.55)	(1.32)	(1.50)	(0.75)	(0.49)
N	1,560	1,560	1,560	1,560	1,548	1,546	1,544	1,540
	Log (output/worker)				Log (output)			
Treatment*Post	0.155	0.163	–0.287	0.139	0.181*	0.257	–0.121	0.105
	(1.42)	(0.99)	(–1.65)	(0.82)	(2.05)	(1.86)	(–0.88)	(0.66)
N	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560

DiD = difference-in-difference, N = number, PSM = propensity score matching.

Source: Authors.

Table A.3. Determinants of Market Exit (Cox proportional hazards model), truncated sample (2005–15)

Variables	**All sample**	**Domestic plants only**	**Foreign-owned and exporting only**	**Foreign-owned and importing only**	**Domestic plant and with import and export**	**Foreign-owned plant and with import and export**
1.flood	1.2885**	1.3189**	1.1051	0.8520	1.7253**	2.3356***
	(0.1384)	(0.1616)	(0.3833)	(0.4898)	(0.3822)	(0.6968)
log_outputR	1.0538*	1.0452	0.9022	1.2143	0.9466	1.2402***
	(0.0308)	(0.0346)	(0.1852)	(0.1882)	(0.0880)	(0.0657)
log_employ	0.5502***	0.4689***	0.5649**	0.6848*	0.6398***	0.7076***
	(0.0359)	(0.0320)	(0.1488)	(0.1543)	(0.0960)	(0.0637)
log_femploy	1.1238***	1.0975***	1.4592***	1.1857	1.3467***	1.1266**
	(0.0296)	(0.0331)	(0.1835)	(0.2149)	(0.0978)	(0.0638)
log_labprod	0.9353**	1.0037	1.0061	0.6625***	1.0545	0.8631***
	(0.0278)	(0.0397)	(0.2350)	(0.0687)	(0.1073)	(0.0470)
sage1	1.0777***	1.1217***	0.9833	1.1590**	1.0861***	1.0416
	(0.0164)	(0.0198)	(0.0586)	(0.0772)	(0.0309)	(0.0325)
sage2	0.8805***	0.8278***	1.1040	0.8154	0.9120**	0.9612
	(0.0221)	(0.0255)	(0.1148)	(0.1056)	(0.0405)	(0.0634)
n_psid	0.9992***	0.9994***	0.9997	0.9999	0.9997	0.9997
	(0.0002)	(0.0002)	(0.0006)	(0.0007)	(0.0004)	(0.0006)
N	97,414	47,433	2,176	1,936	7,025	7,303

Pseudo R-sq.	0.03	0.02	0.08	0.10	0.07	0.06
Chi sq.	1,455.93	1,015.05	79,478.00	2,485,427.65	920.65	79,695.59

N = number.

Source: Authors.

Table A.4 Determinants of Market Entry (Poission regression), truncated sample (2005–15)

Variables	Kabupaten	
	Entry	Exit
Flood = 1; 0 else	74.05	–99.28**
	(1.29)	(–2.70)
Flood*Time	–0.0370	0.0494**
	(–1.30)	(2.70)
No. of plants	0.000483	0.00414***
	(0.70)	(7.39)
Average age	–0.426***	–0.00270
	(–11.36)	(–0.08)
No. of industries	0.000308	–0.0120
	(0.02)	(–1.10)
Kabupaten FE	Yes	Yes
Province FE	No	No
Year FE	Yes	Yes
N	1,109	1,131
Chi-sq.	5,814.4	9,464.8
p-value	<0.0001	<0.0001

FE = fixed effects, N= number.

Source: Authors.

ERIA Discussion Paper Series

No.	Author(s)	Title	Year
2021-43 (no. 410)	Quang Hoan TRUONG and Van Chung DONG	Spillover Effects of Foreign and Domestic Exporting Firms on Export Decisions of Local Manufacturing Firms: Evidence from Viet Nam	December 2021
2021-42 (no. 409)	Ernawati PASARIBU, Puguh B. IRAWAN, Tiodora H. SIAGIAN, Ika Yuni WULANSARI, and Robert KURNIAWAN	Spillover Effects of Social and Economic Interactions on COVID-19 Pandemic Vulnerability Across Indonesia's Region	December 2021
2021-41 (no. 408)	Samuel NURSAMSU, Wisnu Harti ADIWIJOYO, and Anissa RAHMAWATI	Education for All? Assessing the Impact of Socio-economic Disparity on Learning Engagement During the COVID-19 Pandemic in Indonesia	October 2021
2021-40 (no. 407)	Yasuyuki TODO, Keita OIKAWA, Masahito AMBASHI, Fukunari KIMURA, and Shujiro URATA	Robustness and Resilience of Supply Chains During the COVID-19 Pandemic: Findings from a Questionnaire Survey on the Supply Chain Links of Firms in ASEAN and India	September 2021
2021-39 (no. 406)	Irlan Adiyatma RUM	Policy Strategies to Strengthen the Travel and Tourism Sectors from the COVID-19 Pandemic Shocks: A Computable General Equilibrium Model for the Indonesian Economy	September 2021
2021-38 (no. 405)	Tadashi ITO	Identifying the Impact of Supply Chain Disruption Caused by COVID-19 on Manufacturing Production in Japan	September 2021
2021-37 (no. 404)	Gyeong Lyeob CHO, Minsuk KIM, and Yun Kyung KIM	The Global Economic Impact of the COVID-19 Pandemic: The Second Wave and Policy Implications	September 2021
2021-36 (no. 403)	VGR Chandran GOVINDARAJU, Neil FOSTER-MCGREGOR, and Evelyn Shyamala DEVADASON	Regulatory Distance, Margins of Trade, and Regional Integration: The Case of the ASEAN+5	September 2021

2021-35 (no. 402)	Norlin KHALID, Muhamad Rias K. V. ZAINUDDIN, Tamat SARMIDI, Sufian JUSOH, Mohd Helmi ALI, and Faliq RAZAK	The Trade Restrictiveness Index and Its Impact on Trade Performance in Selected East Asian Countries	September 2021
2021-34 (no. 401)	Anming ZHANG, Xiaoqian SUN, Sebastian WANDELT, Yahua ZHANG, Shiteng XU, and Ronghua SHEN	COVID-19, Air Transportation, and International Trade in the ASEAN+5 Region	September 2021
2021-33 (no. 400)	Xiaowen FU, David A. HENSHER, Nicole T. T. SHEN, and Junbiao SU	Aviation Market Development in the New Normal Post the COVID-19 Pandemic: An Analysis of Air Connectivity and Business Travel	September 2021
2021-32 (no. 399)	Farhad TAGHIZADEH-HESARY, Han PHOUMIN, and Ehsan RASOULINEZHAD	COVID-19 and Regional Solutions for Mitigating the Risk of Small and Medium-sized Enterprise Finance in ASEAN Member States	August 2021
2021-31 (no. 398)	Charan SINGH and Pabitra Kumar JENA	Central Banks' Responses to COVID-19 in ASEAN Economies	August 2021
2021-30 (no. 397)	Wasim AHMAD, Rishman Jot Kaur CHAHAL, and Shirin RAIS	A Firm-level Analysis of the Impact of the Coronavirus Outbreak in ASEAN	August 2021
2021-29 (no. 396)	Lili Yan ING and Junianto James LOSARI	The EU–China Comprehensive Agreement on Investment: Lessons Learnt for Indonesia	August 2021
2021-28 (no. 395)	Jane KELSEY	Reconciling Tax and Trade Rules in the Digitalised Economy: Challenges for ASEAN and East Asia	August 2021
2021-27 (no. 394)	Ben SHEPHERD	Effective Rates of Protection in a World with Non-Tariff Measures and Supply Chains: Evidence from ASEAN	August 2021
2021-26 (no. 393)	Pavel CHAKRABORTHY and Rahul SINGH	Technical Barriers to Trade and the Performance of Indian Exporters	August 2021

2021-25 (no. 392)	Jennifer CHAN	Domestic Tourism as a Pathway to Revive the Tourism Industry and Business Post the COVID-19 Pandemic	July 2021
2021-24 (no. 391)	Sarah Y TONG, Yao LI, and Tuan Yuen KONG	Exploring Digital Economic Agreements to Promote Digital Connectivity in ASEAN	July 2021
2021-23 (no. 390)	Christopher FINDLAY, Hein ROELFSEMA, and Niall VAN DE WOUW	Feeling the Pulse of Global Value Chains: Air Cargo and COVID-19	July 2021
2021-22 (no. 389)	Shigeru KIMURA, IKARII Ryohei, and ENDO Seiya	Impacts of COVID-19 on the Energy Demand Situation of East Asia Summit Countries	July 2021
2021-21 (no. 388)	Lili Yan ING and Grace Hadiwidjaja	East Asian Integration and Its Main Challenge: NTMs in Australia, China, India, Japan, Republic of Korea, and New Zealand	July 2021
2021-20 (no. 387)	Xunpeng SHI, Tsun Se CHEONG, and Michael ZHOU	Economic and Emission Impact of Australia–China Trade Disruption: Implication for Regional Economic Integration	July 2021
2021-19 (no. 386)	Nobuaki YAMASHITA and Kiichiro FUKASAKU	Is the COVID-19 Pandemic Recasting Global Value Chains in East Asia?	July 2021
2021-18 (no. 385)	Yose Rizal DAMURI et al.	Tracking the Ups and Downs in Indonesia's Economic Activity During COVID-19 Using Mobility Index: Evidence from Provinces in Java and Bali	July 2021
2021-17 (no. 384)	Keita OIKAWA, Yasuyuki TODO, Masahito AMBASHI, Fukunari KIMURA, and Shujiro URATA	The Impact of COVID-19 on Business Activities and Supply Chains in the ASEAN Member States and India	June 2021
2021-16 (no. 383)	Duc Anh DANG and Vuong Anh DANG	The Effects of SPSs and TBTs on Innovation: Evidence from Exporting Firms in Viet Nam	June 2021
2021-15 (no. 382)	Upalat KORWATANASAKUL and Youngmin BAEK	The Effect of Non-Tariff Measures on Global Value Chain Participation	June 2021
2021-14 (no. 381)	Mitsuya ANDO, Kenta YAMANOUCHI, and Fukunari KIMURA	Potential for India's Entry into Factory Asia: Some Casual Findings from International Trade Data	June 2021

2021-13 (no. 380)	Donny PASARIBU, Deasy PANE, and Yudi SUWARNA	How Do Sectoral Employment Structures Affect Mobility during the COVID-19 Pandemic	June 2021
2021-12 (no. 379)	Stathis POLYZOS, Anestis FOTIADIS, and Aristeidis SAMITAS	COVID-19 Tourism Recovery in the ASEAN and East Asia Region: Asymmetric Patterns and Implications	June 2021
2021-11 (no. 378)	Sasiwimon Warunsiri PAWEENAWAT and Lusi LIAO	A ‘She-session’? The Impact of COVID-19 on the Labour Market in Thailand	June 2021
2021-10 (no. 377)	Ayako OBASHI	East Asian Production Networks Amidst the COVID-19 Shock	June 2021
2021-09 (no. 376)	Subash SASIDHARAN and Ketan REDDY	The Role of Digitalisation in Shaping India’s Global Value Chain Participation	June 2021
2021-08 (no. 375)	Antonio FANELLI	How ASEAN Can Improve Its Response to the Economic Crisis Generated by the COVID-19 Pandemic: Inputs drawn from a comparative analysis of the ASEAN and EU responses	May 2021
2021-07 (no. 374)	Hai Anh LA and Riyana MIRANTI	Financial Market Responses to Government COVID-19 Pandemic Interventions: Empirical Evidence from South-East and East Asia	April 2021
2021-06 (no. 373)	Alberto POSSO	Could the COVID-19 Crisis Affect Remittances and Labour Supply in ASEAN Economies? Macroeconomic Conjectures Based on the SARS Epidemic	April 2021
2021-05 (no. 372)	Ben SHEPHERD	Facilitating Trade in Pharmaceuticals: A Response to the COVID-19 Pandemic	April 2021
2021-04 (no. 371)	Aloysius Gunadi BRATA et al.	COVID-19 and Socio-Economic Inequalities in Indonesia: A Subnational-level Analysis	April 2021
2021-03 (no. 370)	Archanun KOHPAIBOON and Juthathip JONGWANICH	The Effect of the COVID-19 Pandemic on Global Production Sharing in East Asia	April 2021
2021-02 (no. 369)	Anirudh SHINGAL	COVID-19 and Services Trade in ASEAN+6: Implications and Estimates from Structural	April 2021

		Gravity	
2021-01 (no. 368)	Tamat SARMIDI, Norlin KHALID, Muhamad Rias K. V. ZAINUDDIN, and Sufian JUSOH	The COVID-19 Pandemic, Air Transport Perturbation, and Sector Impacts in ASEAN Plus Five: A Multiregional Input–Output Inoperability Analysis	April 2021

ERIA discussion papers from the previous years can be found at:
http://www.eria.org/publications/category/discussion-papers