ASSESSING THE IMPACTS OF FOOD AND MOUTH DISEASE OUTBREAK ON THE INDONESIAN ECONOMY AND ITS REGIONAL GROWTH

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Abstract: Foot and mouth disease (FMD) is typically endemic and commonly found as a recurring issue in many developing countries, including Indonesia. In 2022, FMD has massively spread to 62 districts and cities so that it was declared an outbreak which caused significant economic losses. In this paper, we attempt to assess the impacts of FMD on the Indonesian economy by using a computable general equilibrium (CGE) approach. The results show that the FMD outbreak caused negative pressure on national economic growth, reducing the real wage and consumption, as well as exacerbating trade deficit. The outbreak also induced higher prices of beef and dairy sectors as well as their related sectors. Based on the regional perspective, the main production regions of beef and dairy are expected to suffer higher economic loss than that of other regions. Meanwhile, at the household level, the outbreak caused considerable effect in lowering income and consumption, particularly for rural farm households. Some necessary policies to overcome the outbreak, consisting of establishing a FMD handling post, promoting vaccination, extending financial supports, and maintaining communication and transparency with other countries regarding the outbreak status.

Keywords: Computable General Equilibrium (CGE), Foot and Mouth Disease (FMD), livestock, macroeconomy, regional

Abstrak: Penyakit mulut dan kuku (PMK) merupakan penyakit endemik dan sering ditemukan sebagai masalah berulang di banyak negara berkembang, termasuk Indonesia. Pada tahun 2022, PMK telah menyebar secara masif ke 62 kabupaten dan kota sehingga dinyatakan sebagai wabah yang menimbulkan kerugian ekonomi yang signifikan. Dalam kajian ini, penulis menganalisis dampak PMK terhadap perekonomian Indonesia dengan menggunakan pendekatan Computable General Equilibrium (CGE). Hasil penelitian menunjukkan bahwa wabah PMK menimbulkan tekanan negatif terhadap pertumbuhan ekonomi nasional, menurunkan upah riil dan konsumsi, serta meningkatkan defisit neraca perdagangan. Wabah ini juga menyebabkan terjadinya peningkatan harga daging sapi dan susu segar serta sektor terkait lainnya. Berdasarkan perspektif wilayah, provinsi penghasil utama produk daging dan susu diperkirakan akan mengalami kerugian ekonomi yang lebih besar dibandingkan dengan provinsi lainnya. Sementara itu, di tingkat rumah tangga, wabah PMK menyebabkan dampak yang signifikan dalam menurunkan pendapatan dan konsumsi, terutama bagi rumah tangga petani di perdesaan. Beberapa kebijakan yang diperlukan untuk mengatasi wabah tersebut, antara lain: mendirikan posko penanganan PMK, menggalakkan vaksinasi, memberikan dukungan dana, serta menjaga komunikasi dan transparansi dengan negara lain terkait status wabah PMK.
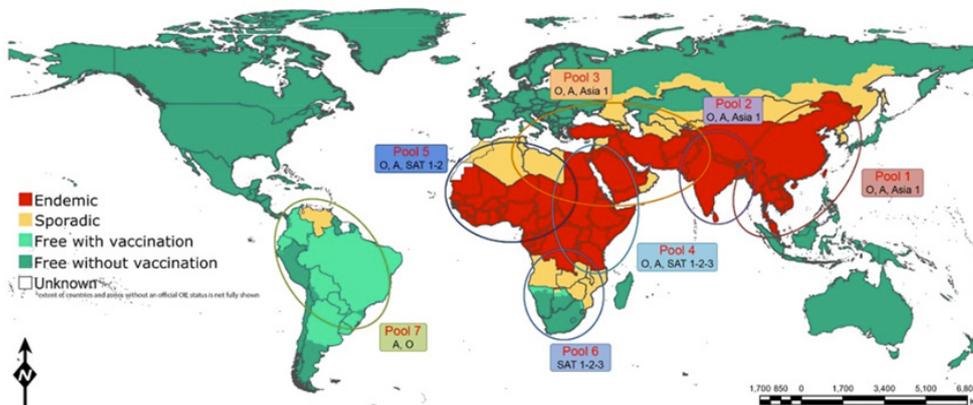
Kata kunci: Computable General Equilibrium (CGE), Penyakit Mulut dan Kuku (PMK), peternakan, makroekonomi, regional

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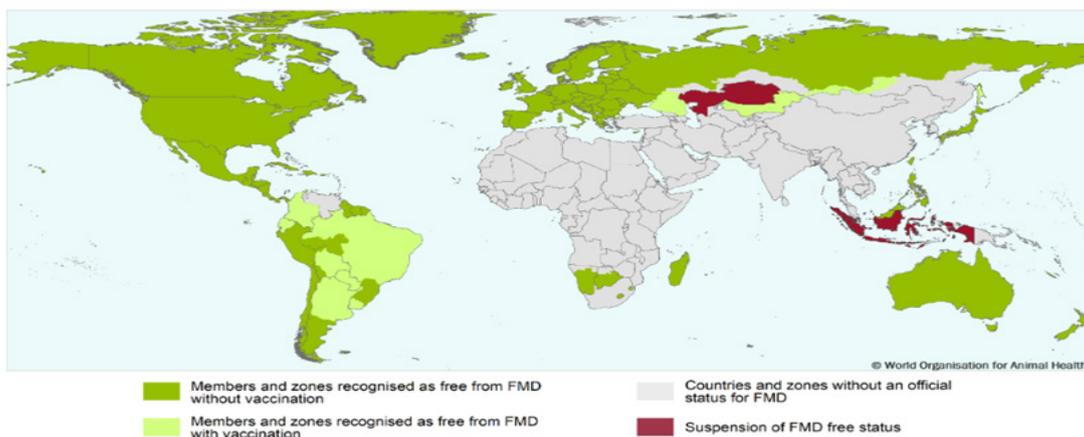Email: sahara@apps.ipb.ac.id

INTRODUCTION

In many developing countries, foot and mouth disease (FMD) is typically endemic and commonly found as a recurring issue. Infected animals not only suffer substantial production losses but also can significantly reduce livelihood. FMD is considered as a livestock disease with a rapid spread rate. It is caused by foot-mouth disease virus (FMDV) with one of its transmission media through the wind (Carter and Saunders 2013). This disease attacks various animals that have cloven hoops, such as cows, buffaloes, sheep, goats, pigs, and others. Indonesia itself has been declared free from FMD since 1986 with a non-vaccination status and is officially recognized by the World Organization for Animal Health (OIE). However, after 35 years of being declared free from FMD, the Indonesian government in May 2022 announced the alleged FMD case in the East Java Province area which includes Gresik, Sidoarjo, Lamongan, and Mojokerto Regencies. This changing status is confirmed in Figure 1 as Indonesian status of FMD shifted from free without vaccination in 2021 to the category of suspension of FMD free status in 2022.

In 2022, FMD has spread to 62 districts/cities in Indonesia so that it was declared an extraordinary event (KLB/outbreak). Based on data from the Ministry of Agriculture (Kementan), FMD outbreak have spread to 24 provinces, 295 districts/cities and 2,574 sub-districts in Indonesia by infecting more than 513 thousand head of livestock. The highest total cases of FMD were in East Java province with the number of infected animals reaching 179 thousand and spread across 38 districts/cities. Then followed by West Nusa Tenggara province with a total of 98 thousand animals spread across 7 districts/cities, and West Java province with a total infected of 60 thousand animals spread over 27 districts/cities. FMD cases in Indonesia indeed infect various types of livestock, ranging from beef cattle, dairy cattle, buffalo, goats, sheep, and pigs. However, if investigated further, beef cattle are the most frequently infected livestock with FMD with a total of 415 thousand heads or 80.95 percent of the total cases of FMD in Indonesia. Then followed by dairy cows with a total of 71 thousand heads or 13.99 percent of the total FMD cases in Indonesia (Ministry of Agriculture 2022). The detailed data of FMD cases and distribution in Indonesia can be seen in Table 1.

(a) Global Food and Mouth Disease (FMD) Status as per 2021

(b) Global Food and Mouth Disease (FMD) Status as per September 2022 (woah.org, 2023)

Figure 1. The Comparison of FMD Status in 2021 and 2022

Table 1. FMD cases and their distribution in Indonesia, August 2022

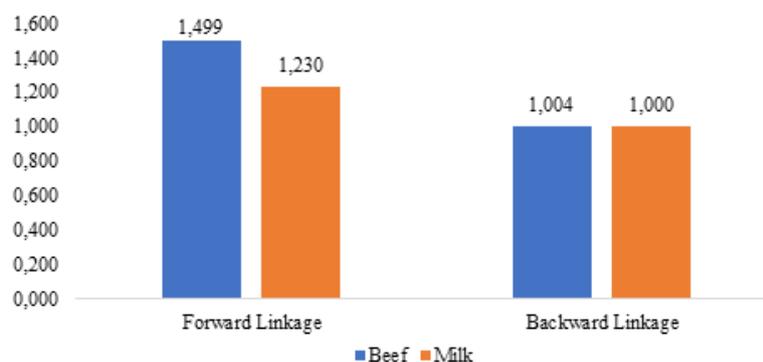| Province	Total Incidence (head)	Total Recovery/ Cured (head)	Total Mortality (head)	Total Regency/ City affected	Total Subdistrict affected
East Java	179,857	110,074	2,171	38	603
West Nusa Tenggara	98,093	77,874	221	7	70
West Java	60,115	47,248	5,476	27	369
Aceh	45,509	44,199	244	20	188
Central Java	42,337	23,639	288	33	456
North Sumatra	22,640	19,293	18	26	158
West Sumatra	19,591	9,587	35	17	133
Yogyakarta	12,869	7,083	431	4	64
Bengkulu	9.128	6,709	49	9	69
Bangka Belitung	4,092	3,914	30	7	33
South Sulawesi	3,803	887	46	20	96
Riau	3,181	2,279	14	9	72
Banten	2,602	2,236	30	7	60
Jambi	2.143	1,720	9	9	44
Lampung	1978	1,761	40	12	36
West Kalimantan	1819	1,709	8	9	29
DKI Jakarta	1048	991	13	5	9
Central Kalimantan	827	437	0	10	22
Bali	556	0	3	9	19
South Kalimantan	531	505	7	4	12
Riau islands	415	389	1	1	9
South Sumatra	271	228	12	8	18
East Kalimantan	51	18	1	3	4
West Sulawesi	15	14	1	1	1
Total	513,471	362,794	9.148	295	2,574

Figure 2. The linkages of the Indonesian livestock sector

FMD outbreak have an impact on economic losses, especially for the Indonesian livestock sector. The major loss due to FMD occurred as a result of milk losses (Jemberu et al. 2014). As we know, beef and fresh milk are the main food providers, especially animal protein. In addition, domestic beef production has contributed 60% to national consumption. Likewise, fresh milk which has contributed 20 percent to national consumption (Tawaf, 2017). FMD threatens the productivity, food security and income of farmers thereby reducing local market opportunities for the sale of livestock, meat and dairy products, as well as milk and dairy products. This is also reinforced by McFadden in Naipospos (2014) which states that losses incurred due to FMD can include: (i) loss of productivity represented by reduction in milk production (25% per year), decreased growth rate of beef cattle (10–20% longer to maturity); loss of employment (60–70% in the

1st month post-infection), decreasing fertility (abortion rate reaches 10%) and slowing pregnancy, child mortality (20–40%) for sheep and pigs), destruction of chronically infected livestock, disruption of domestic trade and livestock management, lost in livestock export opportunities, and high cost of intervention to tackle FMD.

Economic losses in several countries show staggering monetary values. In 1977 Taiwan suffered a loss of $6.61 billion USD, in 2001 Uruguay suffered a loss of $0.08 billion USD, in 2001 the United Kingdom suffered a loss of $9.20 billion USD, in 2010 Japan suffered a loss of $0.05 billion USD and in 2010-2011 Korea lost $2.80 billion USD (Rushton and Knight 2015). Meanwhile, based on Naipospos (2013) the estimated economic loss due to FMD outbreak in Indonesia is IDR 9.60 trillion and according to Firman et al. (2022) economic losses can reach IDR 38.67 trillion.

Further investigations regarding economy wide impacts are probably more important than the outbreak itself. There are reasons for this. First, there are few studies investigated the economic loss due to FMD outbreak in Indonesia which primarily focus on partial analysis perspective (the microeconomic aspect) and less attention on macroeconomic aspects. Consequently, these studies tend to underestimate the impacts. Second, as livestock sector is interlinked with other economics activities, the effects might propagate problems in other sector, neglecting this possibility clearly will miss the bigger and more important picture. The effects of FMD outbreak can go far beyond the livestock sector, such as job losses (Miller et al. 2018), welfare reductions (Hsu et al. 2005), and loss of production and access to international markets (Feng et al. 2017). The negative effects of FMD outbreak can also predominantly fall on lower income workers and households (Menezes et al. 2023). Also, economic losses following this disease can spread over many periods even with a one-time shock (Gohin and Rault, 2013). To the best of our knowledge, no study in Indonesia investigated the impact of the FMD outbreak on macroeconomic and microeconomic performance simultaneously. An early indication for interlinkage between livestock sector and other economic activities can be shown by the so called forward and backward multipliers (Figure 2). In fact, beef and milk sectors have backward and forward linkages of more than unity. This suggests that problems in that sectors will be transmitted more than proportionally to the corresponding upstream and downstream activities. For instance, a squeeze on beef sector equivalent to one rupiah will be translated into about 1.5 Rupiah losses in downstream activities. This is just one example of how indirect effects is far more important than the direct one. Third, and probably the most important, effects on households and farmers need to be integrated. Based on the 2013 agricultural census data, as much as 98% of cattle are cultivated by households or smallholders. Generally, smallholder farms are located in rural areas and are subsistence in nature.

This study attempts to fill the gap in the literature review by assessing the impact of FMD outbreak on macroeconomic and microeconomic performance by using CGE model. This method allows the study team to link macroeconomic and sectoral performance, as well as regional and livelihood status. Specifically, this paper aims to assess the impacts of FMD on: (i) Indonesian macroeconomic performance; (ii) Indonesian sectoral product prices and exports; (iii) Indonesian regional growth; and (iv) Indonesian household income and consumption.

METHODS

To assess the impact of FMD on the Indonesian economic (national level) and its regional sector, the study team performs Recursive Dynamic Computable General Equilibrium (RDCGE) derived from Wayang and INDOF models (Wittwer, 1999; Warr, 1998; Oktaviani, 2001) The main database in the model is built based on the 2016 Indonesian Input-Output Table and Social Accounting Matrix (SAM) which are the latest database available published by Indonesian Statistic Agency (BPS).

The model consists of 185 sectors and 34 regions (provincial level). The disaggregation of households includes (1) Rural 1: agricultural labourers in rural areas, (2) Rural 2: agricultural entrepreneurs in rural areas, (3) Rural 3: low-class free entrepreneurs, administrative personnel, itinerant traders, free workers in the transportation sector, personal services, and unskilled labourers in rural areas, (4) Rural 4: non-labour force and unclear groups in rural areas, (5) Rural 5: upper-class freelancers, non-agricultural employers, managers, military, professionals, technicians, teachers, administrators and upper-class sales in rural areas, (6) Urban 1: lower class freelancers, TU workers, peddlers,

transport freelancers, personal services and unskilled labourers in urban areas, (7) Urban 2: non-agricultural workers and unclear groups in urban areas, and (8) Urban 3: upper-class freelancers, non-agricultural employers, managers, military, professionals, technicians, teachers, administrators and upper-class sales in urban areas. The grouping of households utilized to illustrate income distribution, and rural 1-2 plus urban 1 represents the farmer's households.

The theoretical structure in the CGE Model usually consists of a system of equations that describes the demand for labour, demand for production factors, demand for intermediate inputs, demand for combined factor inputs and intermediate inputs, demand for combinations of output, demand for investment goods, household demand, exports, and demand. At the other end, margin demand, selling price, market balance, indirect taxes, GDP based on income and expenditures, trade balance, rate of return on capital, investment and capital accumulation and debt accumulation, as well as regional extension.

Microeconomic behavior is assumed to be in a state of maximizing profit for each producer and maximizing utility for consumers. In the simulation carried out in this research, the final product market, intermediate product, and production factors are assumed to be in equilibrium and determined endogenously in the model. The theoretical foundation of the production structure in the CGE Model explains that one industry does not correspond to one commodity, as it can produce several commodities. It also demands intermediate and primary inputs in the form of labour and capital from the domestic market and imports. Meanwhile, land input is sourced domestically. CES was used in the production function to represent assumptions of the separability of input and output in a multistage production structure. The additional assumption of Leontief technology in adopting fixed proportions was made in the composite demands of both intermediates and primary aggregate factors. There are two important behavioral properties of the production structure, assuming that agents involved in the markets are price takers and act rationally to maximize profits by using the most efficient combination of inputs according to the available level of technology. In each production

process, each industry is assumed to single commodity. These sectors use primary factors and intermediate inputs. Any intermediate inputs can be obtained from both the domestic and import markets. The primary factors used are labour, land, and capital. Some basic assumptions that must be considered are: (1) separation between input and output (separable), (2) tiered stages and (3) hierarchical structure based on CES (transformation). From the production structure, it can be derived directly regarding the demand for primary factors and intermediate inputs. Primary factor demand is determined based on the production function, while the intermediate input demand is proportional to the output type.

To assess the FMD outbreak in Indonesia, the study team performs two scenarios by using the magnitude of shock based on the data from USDA (2022), reporting that post-outbreak production in the livestock sector caused by FMD is 30 percent lower than that of the normal production rate. The first scenario is the decline in Indonesia's dairy production by 30% due to FMD, and the secod scenario is the decline in Indonesia's dairy and beef production, each by 30% due to FMD. This scenario differs from the scenario conducted by Countryman and Hagerman (2017) which incorporated the production and trade losses as shocks to the CGE Model. Concern over trade losses is validated by the implementation of trade bans of to curb infection following the FMD outbreak (Alhaj, 2017).

Based on the previous literature, we hypothesize that FMD will bring negative impacts on (i) Indonesian macroeconomic performance; (ii) Indonesian sectoral product prices and exports; (iii) Indonesian regional growth; and (iv) Indonesian household income and consumption. The research framework of the study is shown in Figure 3. Indonesia had been declared free from Foot and Mouth Disease (FMD) for 35 years, but it reappeared again in May 2022. The FMD surely causes Indonesia's economic loss. The studies addressing the impact of FMD on Indonesia's economy are still limited. Thus, analysing the impact of FMD becomes important and has been the main goal of this study. To assess the impact, this study uses Recursive Dynamic Computable General Equilibrium (RDCGE).
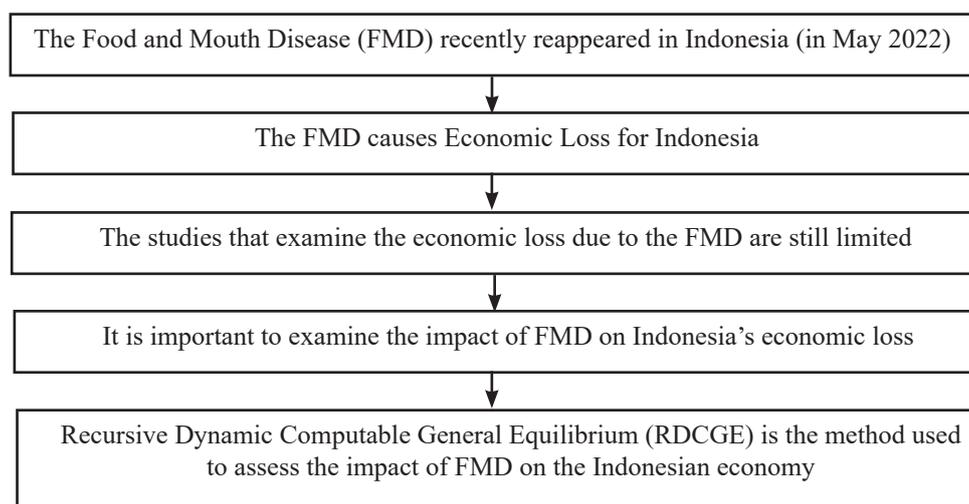
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Figure 3. Research Framework

RESULTS

The Impact of Foot and Mouth Disease (FMD) on the Indonesian Macroeconomic Performance

Results show that FMD outbreaks brought negative impacts on Indonesian economy including national (macroeconomy), regional, and sectoral level. To be more specific, the impact of the Foot-and-Mouth Disease (FMD) on Indonesia's macroeconomy is estimated for a number of indicators, namely: GDP, household consumption, export and balance of trade, and real wage (Table 2).

Simulation 1 shows that Indonesia's GDP fell 0.043%, or in 2022 the loss is equivalent to IDR 5.04 trillion. Meanwhile, simulation 2 shows that GDP fell 0.249% or equivalent to IDR 29.2 trillion. The livestock sub-sector in Indonesia contributes around 28.191 % of Indonesia's agricultural sector and 1.5% of its total GDP. Therefore, it is expected that the FMD outbreak has a profound and direct impact on the livestock sub-sector and potentilly ti the economy. The results are similar to the studies conducted in New Zealand (Forbes and Van-Halderen, 2014) and Australia (Buetre et al. 2013) reporting the negative impact of FMD on GDP. Despite the same direction, the magnitude of the estimated GDP contraction due to large FMD outbreak scenario differ. It is expected that the total economic loss in terms of GDP is lower in Indonesia, in comparison to the main dairy and beef producing countries like Australia and New Zealand. Based on Forbes and Van-Halderen (2014) and Buetre et al. (2013), both New Zealand and Australia GDP reduced by 5 percent and 0.16 percent, respectively. The difference in the results have been attributed to specific underlying factors namely consumer profile and behavior, the value of livestock factors, the positioning in the global market, as well as the biosecurity policy measures (Schoenbaum and Disney, 2003).

The decrease in dairy products will have an impact on household consumption. The simulation predicts a decline in consumption of up to 0.076% for scenario 1 and 0.464% for scenario 2. BPS reported that per capita expenditure on beef and dairy product were accounted for around 2.66% and 2.67% of total expenditure. Although their portions are relatively small, the reduction in consumption of dairy and beef can contribute to a decrease in total household expenditure. It is also important to note that per capita consumptions of dairy and beef in Indonesia are lower than the global average consumption. Data for 2022 shows that consumption of dairy products per capita was only 16.27 kg/capita which is classified into low category (under 30 kg/capita) according to FAO. Meanwhile, the average beef consumption in Indonesia is only 2.23 kg/capita, which is lower than the world average of 6.4 kg/capita. Thus, FMD outbreak in Indonesia presents a challenge for efforts to increase the consumption of dairy and beef in order to catch up with consumption levels of other countries.

Table 2. Simulation Results of FMD Impact on Indonesia's Macroeconomy

Macroeconomics Indicator	Baseline data based on Input Output Table 2016 (IDR)	Results of Simulation 1 (% Change)	Results of Simulation 2 (% Change)
GDP	12,646 Trillion	-0.043	-0.249
Household consumption	12,581 Trillion	-0.076	-0.464
Export	2,379 Trillion	-0.019	-0.109
Balance of trade	65 Trillion	-0.005	-0.019
Real wage	4,931 Trillion	-0.078	-0.203

Note:
Sim 1 = The decline in Indonesia's dairy production by 30% due to FMD
Sim 2 = The decline in Indonesia's dairy and beef production, each by 30% due to FMD

The simulation results also show that exports fell by around 0.019% and the balance of trade fell by 0.005% for scenario 1. As for scenario 2, there is a decrease in exports of around 0.109% and a decrease in the balance of trade around 0.019%. Considering Indonesia is a net importer country for dairy and beef products, the FMD outbreak will reduce domestic production and force Indonesia to increase imports to meet domestic demand.

As an indirect impact, the decrease in the domestic production and increased imports can have an impact on rising prices, thereby reducing purchasing power. This can be reflected in the impact on real wages. The simulation shows that real wages will decrease by around 0.078% in scenario 1 and 0.203% in scenario 2. Reducing real wage leads to reducing in household consumption.

The Impact of Foot and Mouth Disease (FMD) on The Indonesian Sectoral Product Prices and Exports

FMD bring impacts on inflation as well. Table 3 shows that some output prices are increasing due to FMD, both in SIM 1 and SIM 2. On average, the FMD causes high prices on milk and livestock produces. This could lead to inflation. Based on SIM 1, fresh milk becomes product that get the highest impact on its price (increase 39.689%). However, the estimated impact on price of fresh milk is lower than the reported value in the United States. Boisvert et al. (2012) pointed out that FMD outbreak in the United States caused significant increase in fresh milk prices by over 65%. In addition, the inelastic demand is also believed to be the other contributing factor to this price hike. Increasing in

price of fresh milk is also followed by prices of food and drinks from milk that increase 5.796% and also prices of processed animal food that increase 1.329%. Because in SIM 1, the FMD could lower the milk production, which decreases the supply for fresh milk as well as foods and drinks made from milk. This then causes increasing in those prices. Aside from that, with the lower produces of milk due to FMD, the producers tend to convert their business into other livestock. They will need to buy new animal food for their new livestock. It could cause increasing in processed animal food prices.

According to SIM 2, when FMD causes lower meat and milk production, this will increase prices of livestock and their products (except fresh milk) by 42.89%, prices of fresh milk by 42.62%, animal slaughter produces by 8.213%, also foods and drinks (made from milk) prices by 5.865%. This is because, meat and milk productions are the main supplies for those products. The rise in beef and milk prices are also consistent with Nogueira et al. (2011). Depopulation of cows due to the FMD outbreak resulted in reducing supply and it is expected to recover and adjust slowly to reach the new level of equilibrium price.

The impact of FMD aside from the price and Indonesia's macro conditions, can also affect export performance. In accordance with the simulations carried out in this study, that there are two simulations, simulation 1 is when there is a decrease in Indonesian cow's milk production by 30% due to FMD, and simulation 2 is when there is a decrease in Indonesian cow's milk and beef production each by 30% due to FMD. The impact is shown in detail in Table 4.

Table 3. The Impact of FMD on Indonesia's Product Prices

Price	SIM 1	Price	SIM 2
Fresh Milk	39.689	Livestock and their products except fresh milk	42.89
Foods & Drinks from Milk	5.796	Fresh milk	42.62
Processed Animal Food	1.329	Animal slaughter produces	8.213
Tubers	0.676	Foods & Drinks from Milk	5.865
Corn	0.675	Processed Animal Food	5.13
Poultry	0.614	Tubers	3.309
Livestock produces	0.564	Corn	3.042
Other produces from livestock	0.494	Poultry	2.649
Sweet potato	0.476	Agriculture, forestry, and fisheries services	2.645
Other produces from forest	0.453	Processing and preservation of meat	2.559
Agriculture, forestry, and fisheries services	0.445	Other produces from forest	2.504
Other nuts	0.392	Other animal produces	2.324
Peanut	0.387	Sweet potato	2.273
Cassava	0.371	Decorative plants	2.155

Note:
SIM 1 = The decline in Indonesia's dairy production by 30% due to FMD
SIM 2 = The decline in Indonesia's dairy and beef production, each by 30% due to FMD

Table 4. The Impact of FMD on Indonesia's Sectoral Exports

Export	SIM 1	Export	SIM 2
Fresh Milk	-15.14	Livestock and Their Products except Fresh Milk	-16.072
Foods&Drinks from Milk	-2.785	Fresh milk	-16.002
Processed animal feed	-0.658	Animal slaughter produces	-3.868
Tubers	-0.336	Foods&Drinks from Milk	-2.82
Corn	-0.336	Processed Animal Food	-2.467
Poultry	-0.305	Tubers	-1.613
Livestock produces	-0.281	Corn	-1.485
Other produces from livestock	-0.246	Poultry	-1.298
Sweet potato	-0.237	Processing and preservation of meat	-1.256
Other produces from forest	-0.226	Other produces from forest	-1.228
Other nuts	-0.196	Other animal produces	-1.142
Peanut	-0.193	Sweet potato	-1.117
Cassava	-0.185	Decorative plants	-1.06
Another plantation produces	-0.181	Sugarcane	-1.045
Decorative plants	-0.175	Peanut	-1.037

Note:
SIM 1 = The decline in Indonesia's dairy production by 30% due to FMD
SIM 2 = The decline in Indonesia's dairy and beef production, each by 30% due to FMD

FMD that attacks cattle will certainly make importing countries avoid buying processed beef products from Indonesia because of the fear that Indonesian products will be contaminated by the disease. This has caused a decline in export performance from Indonesia, especially for processed beef products, as shown in Table 4. In SIM 1, the sector that experienced the largest decline in exports was the fresh milk sector, where the simulated decline in exports was 15.140%. Then followed by the food and beverage sector from milk which experienced a decline in exports of 2.785%. The fresh milk sector as well as the food and beverage sector from milk require the main input in the form of milk products from dairy farming businesses. Thus, a decrease in cow's milk production from the dairy cattle business due to FMD will certainly have a significant impact.

In SIM2, the sector that experienced the largest decline in exports was the livestock sector and its products, as well as fresh milk, where the simulated decline in exports was 16.072% and 16.002%, respectively. This was followed by the slaughter sector, as well as food and beverage from milk, which experienced a decline in exports of 3.868% and 2.820%, respectively. In SIM 2, it is simulated that FMD will cause a decrease in milk and beef production, of course this will reduce exports from the fresh milk, livestock products, and slaughter products sector which are included in the sector that produces milk and beef. While the food and beverage sector from milk is a sector that requires input in the form of fresh milk.

FMD is also expected to suppress the performance of several non-livestock sectors which have strong backward linkage with cow milk and beef sectors. Decreasing cow milk and beef output will reduce the demand for several key inputs such as processed animal feed, corn, and sweet potatoes and hence decrease its capacity to export. Based on the Input Output Table, the use processed animal feed in cow milk sector reached 76.293%, sweet potatoes (0.279%), and corn (0.176%). Similarly, these non-livestock sectors are also considered as key inputs for beef production. The use of processed animal feed, sweet potatoes, and corn is 70.183%, 0.087%, and 0.257% respectively. Aside of that, poultry meat has been considered as a substitute for beef and milk as source of protein foods. FMD shocks in beef and milk production will raise the domestic demand for poultry and consequently reduce exports.

The Impact of Foot and Mouth Disease (FMD) on the Indonesian Regional Growth

FMD also bring negative economic growth on regional level in Indonesia (Figure 4). All 34 provinces in Indonesia experience negative economic growth because of FMD, particularly for the provinces that are the main production zones of beef cattle and dairy cattle in Indonesia. Based on data from Statistics Indonesia (2021a, 2021b), East Java, Central Java, South Sulawesi, NTB, and NTT are the top five areas with the highest population of beef cattle, while East Java, Central Java, West Java, North Sumatera, and Yogyakarta becomes the top five areas with the highest population of dairy cattle. Bali and Lampung

also experience high negative growth due to FMD. This is because those two regions are included as the main locations and main port of agricultural products quarantine before exported to other countries (Media Indonesia, 2022).

With those discussion, which are the impact of FMD on prices, regional growth, sectoral exports, as well as Indonesia's macroeconomy, this will reduce the household income. As presented in Table 5, in all rural and urban area, the household income and consumption are reduced in both two simulations. This is because FMD lead to a slowed down business on beef and dairy cattles, which reduce milk and meat productions. Farm households (rural 1 and rural 2) experienced the biggest income and consumption reduction compared to other household groups. The predicted loss of income and consumption tend to be higher in the rural agricultural households that have high dependency on livestock sector supporting their livelihood (Shankar et al. 2012). Subsequently, this effect will also pose a higher risk on the food and nutritional security levels in the rural areas (Jemberu et al. 2014)

Considering the potential impacts of FMD on the macroeconomy, it is necessary to implement necessary policies to overcome FMD. Several efforts to stop the spread of the virus can be conducted through quarantine, elimination of source of the disease, decontamination, and vaccination (Perry and Rich, 2007). This situation can have an impact on changes in the cost structure of livestock businesses, which can increase additional costs in the form of vaccinations, ongoing control programs, FMD control, and management which create large costs. Furthermore, these control programs are often difficult to discontinue (Knight-Jones and Rushton, 2013). Although the programs have cost and budget consequences, there are several positive impacts including: (1) reducing the risks for vulnerable livestock sub-sector communities, (2) providing convenience to dairy and beef consumers, and (3) potentially can increase the competitiveness of Indonesia's dairy and beef products in international market. Based on the study on another country, the investment in the disease control was economically profitable and can serve as an effective tool for refining policy decisions on FMD control programs (Alhaji et al. 2020) and beneficial to farmers (Seitzinger et al. 2022).

	Aceh	North Sumatra	West Sumatra	Riau	Riau islands	Jambi	South Sumatra	Bangka Belitung	Bengkulu	Lampung	Jakarta	Banten	West Java	Central Java	Yogya-karta	East Java	Bali
SIM 1	-0.03	-0.05	-0.02	-0.04	-0.03	-0.02	-0.02	-0.01	-0.03	-0.05	-0.01	-0.02	-0.01	-0.04	-0.03	-0.04	-0.04
SIM 2	-0.23	-0.31	-0.17	-0.20	-0.16	-0.17	-0.17	-0.11	-0.17	-0.35	-0.07	-0.18	-0.14	-0.25	-0.24	-0.24	-0.31

	NTB	NTT	West Kaliman-tan	Central Kaliman-tan	South Kaliman-tan	East Kaliman-tan	North Kaliman-tan	North Sulawesi	Goron-talo	Central Sulawesi	West Sulawesi	South Sulawesi	Southeast Sulawesi	Maluku	North Maluku	West Papua	Papua
SIM 1	-0.03	-0.03	-0.03	-0.04	-0.03	-0.01	-0.03	-0.03	-0.03	-0.01	-0.04	-0.03	-0.02	-0.03	-0.02	-0.01	-0.01
SIM 2	-0.26	-0.24	-0.21	-0.22	-0.25	-0.09	-0.19	-0.20	-0.23	-0.10	-0.23	-0.25	-0.13	-0.19	-0.14	-0.08	-0.09

Note:

SIM 1 = The decline in Indonesia's dairy production by 30% due to FMD

SIM 2 = The decline in Indonesia's dairy and beef production, each by 30% due to FMD

Figure 4. The Impact of FMD on Regional Growth in Indonesia

Table 5. The Impact of FMD on Household Income and Consumption

Household Income	SIM 1	SIM 2	Household Consumption	SIM 1	SIM 2
rural1	-0.050	-0.283	rural1	-0.080	-0.483
rural2	-0.047	-0.269	rural2	-0.077	-0.469
rural3	-0.047	-0.269	rural3	-0.078	-0.469
rural4	-0.044	-0.255	rural4	-0.075	-0.453
rural5	-0.045	-0.275	rural5	-0.076	-0.474
urban1	-0.042	-0.245	urban1	-0.073	-0.445
urban2	-0.042	-0.251	urban2	-0.073	-0.451
urban3	-0.021	-0.133	urban3	-0.052	-0.332

Note:

SIM 1 = The decline in Indonesia's dairy production by 30% due to FMD

SIM 2 = The decline in Indonesia's dairy and beef production, each by 30% due to FMD

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

By using the CGE approach, the paper provides a more comprehensive approach compared to previous studies in assessing the impact of FMD outbreak. The CGE model allows the study team to investigate the FMD impact on the Indonesian economy both from macroeconomic and microeconomic perspectives. Results show that the FMD outbreak reduces economic growth both at the national and regional levels, export, household consumption, and real wage. From the sectoral aspect, the outbreak leads to increase on sectoral prices particularly on beef and dairy sectors as well as their related sectors. The outbreak also reduces household income and consumption particularly for farm households.

Recommendations

Considering the negative impact, efforts to overcome FMD outbreak are timely to be performed by policy makers and other relevant stakeholders, including: (1) improve the transparency and local government to declare the FMD outbreak so that treatment can be carried out timely. Specific Standard Operating Procedure (SOP) are needed that must be implemented if an area experiences an FMD outbreak, (2) establishing an FMD handling post as a center for further information and research in order to overcome this FMD, (3) acceleration of vaccination in livestock. This also needs to be supported by sufficient animal health workers, therefore, the vaccination throughout Indonesia can be carried out quickly and accurately, (4) consistency in the implementation of vaccination, which also needs to be supported by enabling financial conditions, (5) communication with other countries in the world, regarding the outbreak situation in Indonesia, as well as regarding international trade, particularly related to Indonesian livestock products (milk and livestock products, as well as the flow of foreign tourist, and (6) Supporting the affected breeders with financial support to restart their business.

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