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Uniting A Diverse Indonesia: Tackling Food Price Disparity Through Domestic Port Connectivity

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ABSTRACT

The availability and improvement of port operations theoretically can lead to better connectivity that reduces logistics costs and subsequently prices. This study aims to illustrate how the availability and quality of port infrastructure helps reduce food price disparity in Indonesia. This research uses panel data on the provincial level from 2007 to 2015 and since port variables are time-invariant, Pooled Least Squares and Random Effect have been employed to determine the effect of port infrastructure availability on food prices. Furthermore, to address the endogeneity problem the Two-Stage Least Squares and Hausman-Taylor regression have also been employed. The estimation results show strong evidence that the availability of commercial ports does indeed influence food price and has the potential to generate a faster flow of goods, which may lead to lower distribution costs. Moreover, it was also found that rent-seeking behavior in weigh station management and unbalanced industrial development may lead to the problem of empty backhaul and to higher food prices. Specifically, this study provides new insights into the price control policies that exist in an archipelagic country such as Indonesia by providing empirical evidence where the supply-side policy, i.e. improving port infrastructure, is vital in reducing price disparity.

ملخص

من الناحية النظرية، يمكن أن يؤدي توافر عمليات الموانئ وتحسينها إلى تعزيز الربط بين المناطق الذي يقلل من تكاليف اللوجستيات ومن الأسعار فيما بعد. وتهدف هذه الدراسة إلى توضيح الطريقة التي يساعد من خلالها توافر البنية التحتية للموانئ وجودتها على تقليل التفاوتات في أسعار الغذاء في

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إندونيسيا.ويستخدم هذا البحث بيانات الفريق على مستوى المقاطعات ما بين 2007 و 2015، وبما أن متغيرات الموانئ ثابتة زمنيا، فقد تم استخدام المربعات الصغرى المجمعة والتأثير العشوائي لتحديد تأثير توافر البنية التحتية للموانئ على أسعار المواد الغذائية. وعلاوة على ذلك، لمعالجة مشكلة التجانس، تم أيضا استخدام المربعات الصغرى في مرحلتين وانحدار Hausman-Taylor. وتظهر نتائج التقديرات دليلا قويا على أن توافر الموانئ التجارية يؤثر بالفعل على أسعار الأغذية ويمكن أن يولد تدفقا أسرع للسلع، مما قد يؤدي إلى انخفاض تكاليف التوزيع. كما وجد أن سلوك البحث عن الإيجار في إدارة محطات الوزن والتنمية الصناعية غير المتوازنة قد يؤدي إلى مشكلة رحلات العودة الفارغة وارتفاع أسعار المواد الغذائية. وعلى وجه التحديد، تقدم هذه الدراسة رؤى جديدة حول سياسات مراقبة الأسعار الموجودة في بلد أرخبيلي مثل إندونيسيا من خلال تقديم أدلة تجريبية حيث تكون سياسة جانب العرض، أي تحسين البنية التحتية للموانئ، حيوية في الحد من التفاوت في الأسعار.

ABSTRAITE

La disponibilité et l'amélioration des opérations portuaires peuvent théoriquement conduire à une meilleure connectivité qui réduit les coûts logistiques et par conséquent les prix. Cette étude vise à illustrer comment la disponibilité et la qualité des infrastructures portuaires contribuent à réduire la disparité des prix alimentaires en Indonésie. Cette recherche utilise des données de panel au niveau provincial de 2007 à 2015 et puisque les variables portuaires sont invariantes dans le temps, les méthodes les Moindres carrés regroupés et les Effets aléatoires ont été utilisées pour déterminer l'effet de la disponibilité des infrastructures portuaires sur les prix des aliments. En outre, pour résoudre le problème de l'endogénéité, les régressions des moindres carrés à deux étapes et de Hausman-Taylor ont été également utilisées. Les résultats de l'estimation montrent clairement que la disponibilité de ports commerciaux influence effectivement le prix des denrées alimentaires et qu'elle a le potentiel de générer un flux plus rapide de marchandises, ce qui peut conduire à une baisse des coûts de distribution. En outre, il a été également constaté qu'un comportement de recherche de rente dans la gestion des stations de pesage et un développement industriel déséquilibré peuvent conduire au problème des retours à vide et à des prix alimentaires plus élevés. Plus précisément, cette étude apporte un nouvel éclairage sur les politiques de contrôle des prix qui existent dans un pays archipel comme l'Indonésie en fournissant des preuves empiriques où la politique de l'offre, c'est-à-dire l'amélioration des infrastructures portuaires, est vitale pour réduire la disparité des prix.

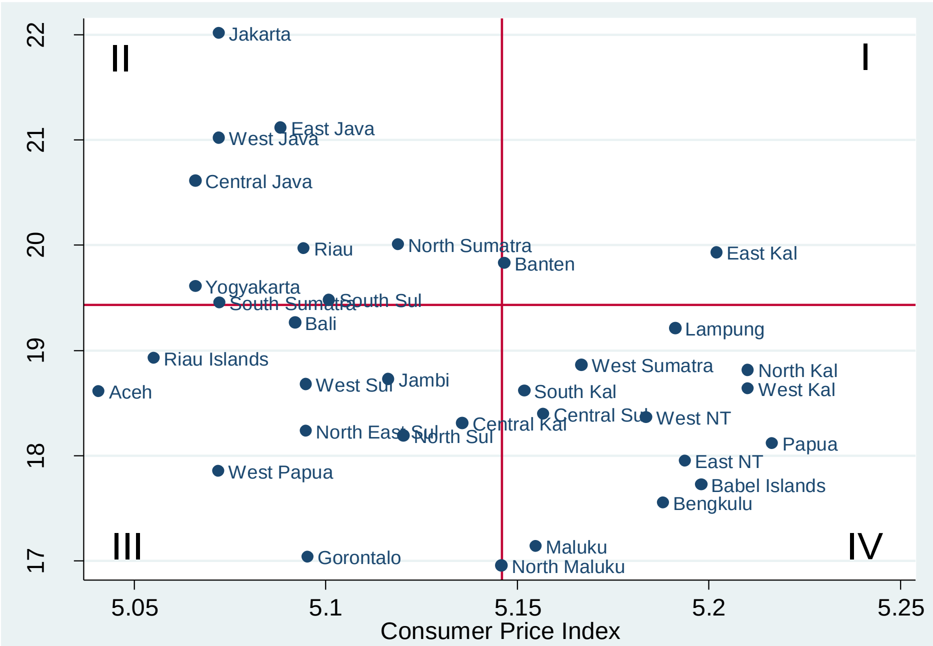
Keywords: Price, Infrastructure, Ports, Logistics

JEL Classification: E31, H54, L92

1. Introduction

Unity in Diversity is the national motto of Indonesia, an archipelagic country with over 17,000 islands. However, Marks (2010) has doubts as to whether that phrase can be applied in an economic perspective. The arguments that arise generally come from a rising Gini coefficient, which means that income is not distributed with preference to lower income families (World Bank, 2016). Not only is Indonesia divided as a whole, it is also divided across regions. As indicated by Figure 1, the majority of provinces outside Java and Sumatera either have low income combined with low price levels (quadrant III; such as West Papua, North Maluku and Gorontalo), or worse, low income combined with high price levels (quadrant IV; such as Papua, Maluku, and West and East Nusa Tenggara). People in western Indonesia, particularly in Java, enjoy a higher standard of living compared to people in eastern Indonesia.

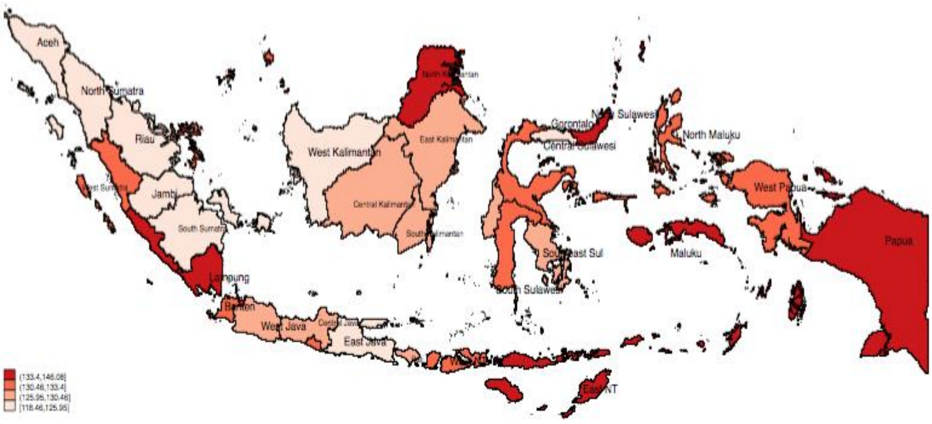
Figure 1: Real Gross Domestic Product and Consumer Price Index in Indonesian Provinces, Average 2007-2015



*Both in natural logarithm

Source: Statistics Indonesia, 2007-2015, calculated

Figure 2: Food Price Index in Indonesian Provinces, 2015



Source: Statistics Indonesia, 2015, calculated

This price disparity across regions also shows a lack of integration within the Indonesian market. As indicated by Figures 1 and 2, glaring disparities in both aggregate prices (CPI) and food commodity prices exist between regions, and prices in the eastern part of Indonesia (mostly those in quadrant IV of Figure 1 or the eastern part of Indonesia in Figure 2) are significantly higher. This decreases the real welfare of the people in the region, especially since in the region, households allocate more of their income to food commodities than to other commodities (AIPI, 2015). It is very important then, from an economic point of view, to resolve this problem in order to unite Indonesia.

Since different price levels across regions in Indonesia may arise from an unintegrated market, better domestic connectivity may well be a solution. Based on the Masterplan on Acceleration and Expansion of Indonesia Economic Development 2011-2015, domestic connectivity can be defined as connectivity between regions (provinces and islands) within Indonesia, which can be achieved by creating an integrated system of national logistics, a national transportation system, and regional development. In this scenario, the government would supply the main impetus in the development of domestic connectivity by identifying the transportation hubs and distribution centers that meet the logistical needs for primary and supporting commodities (Coordinating Ministry of Economic Affairs, 2011). As also can be seen from Figure 1 and 2, the logistic infrastructure that may play a significant role in uniting the domestic markets of Indonesia itself, as an archipelagic country is port infrastructure, especially since the major ports of Indonesia are located in the Java, the western part of Indonesia. As can be seen in Figure 1, provinces in the Java Island are in quadrant II, again corroborate the significant role of port infrastructure.

Therefore, this study looks at how transportation infrastructure development--mainly ports--affects price levels in Indonesia, especially with regard to food commodities. The emphasis on food commodities stems from the fact that in Indonesia, income allocation for food for lower income families is relatively high compared to other commodities (Pratikto, Ikhsan, and Mahi, 2015). Therefore, a rise in the price of food is generally more detrimental to the poor than to the rich. Poverty figures show that the provinces with the highest relative poverty are those in eastern Indonesia, adding to the arguments in favor of lowering food prices in this region[3].

Another argument for why increasing the quality and quantity of port infrastructure will lead to lower food price disparity is that the inflation of food prices in emerging economies, which includes Indonesia, has mostly to do with structural or supply shocks (Cheung et al., 2008; Affandi, 2011; Anand, Ding, and Tulin, 2014). Gregorio (2012) states that it is not sufficient to deal with inflation caused by structural shocks by using monetary policies alone, and this indeed applies to Indonesia. Inflation needs to be adjusted through a creation of policies to address structural problems, and the particular structural issue in the economy will determine what kind of structural policy is adopted. Indonesia's economic and social development is being stunted by one particular structural issue—the quality and quantity of its port infrastructure, which leads to, at least partially, a structural bottleneck, and that in turn inhibits connectivity domestically.

This study is important because there does not seem to have been any detailed empirical research on how port infrastructure affects food prices in Indonesia. This price disparity is also one of the critical problems that

[3] According to Indonesia's Central Statistic Agency data, the figures in September 2017 show that eastern provinces such as Papua, West Papua, East Nusa Tenggara, Maluku, North Maluku, and Gorontalo are the provinces with the highest levels of poverty in relative terms.

contribute to an increasingly divided Indonesia, and it is important to address this issue to ensure that Indonesia's national motto is in line with its economic standpoint. Moreover, as explained in detail in the methodology section, this study also explains which type of transport is the most appropriate to interconnect Indonesia, integrate markets, and subsequently lower food prices in eastern Indonesia.

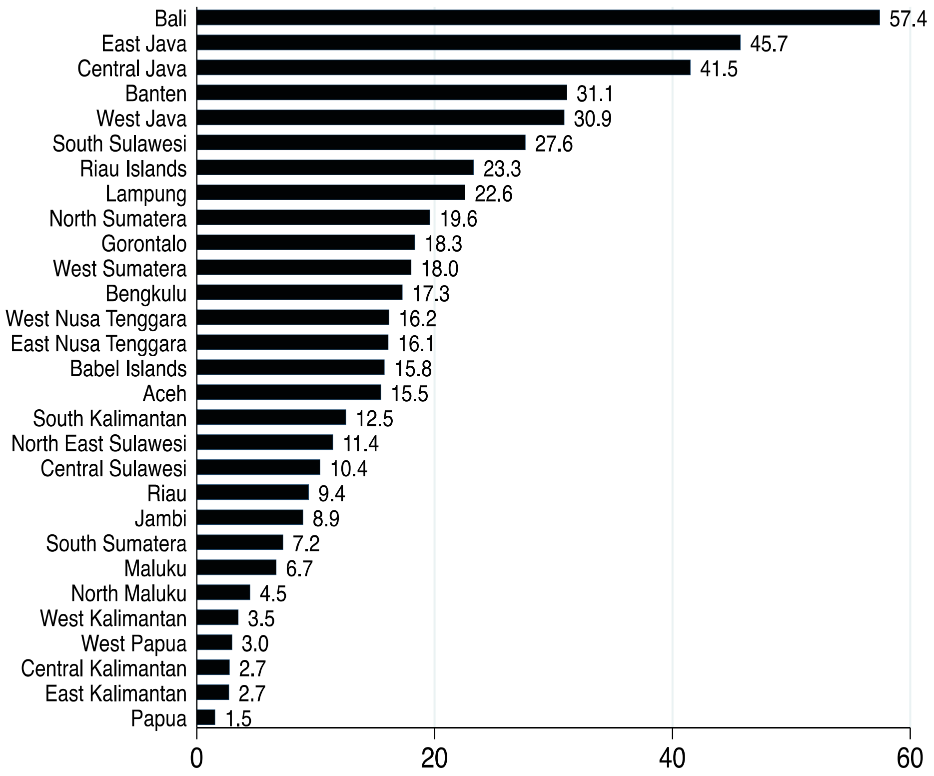
The outline of this paper is as follows: Section 1 lays out the inspiration that initiated this study; Section 2 provides a brief review of the infrastructure in the Indonesian transportation system and its development in recent years; Section 3 presents the literature review and past studies related to this topic; Section 4 provides a summary of the model used, various econometric strategies, and the data set used in the analysis; the interpretation and discussion are presented in Section 5; and finally, Section 6 provides a brief summary and presents some implications for policy-making.

2. Indonesian Transport Infrastructure

Indonesia's geographical conditions and the distribution of industry and resources present a major challenge for creating an efficient logistics system. Most Indonesians—around 60% of the population—live in Java, which is also the center of the manufacturing industry. Therefore, areas outside Java import most products and commodities from Java. However, according to a study by the World Bank (2010), the cost of shipping a 40-foot container from Padang on the coast of West Sumatra to Jakarta was around US$600, while the same container transported from Jakarta to Singapore cost only US$185, despite Singapore being further away.

Basri and Munandar (2009) state that the existing infrastructure regarding transportation in Indonesia does not make it possible for businesses to distribute products in a cost-efficient way. This includes both road and port infrastructure, which are the modes of transportation that are most commonly used to transport goods and commodities. As shown in Figure 3, the density of roads in good condition (the coverage of roads in good condition with respect to the total land area) in eastern Indonesian provinces such as Papua and West Papua, Maluku and North Maluku is significantly lower than the road density in the western part of Indonesia, especially that in Java and Bali.

Figure 3: Percent of Roads in Good Condition, Average 2007-2015



Source: Transportation Statistics, Statistics Indonesia, 2007-2015, calculated

Despite the fact that Indonesia is an archipelagic nation, its port infrastructure has not yet been fully developed. The Logistic Performance Indicators (LPI) 2010 (Arvis et al. 2010) show that Indonesia's port infrastructure at that time was substandard when compared to its land and air infrastructure. The World Bank's Global Competitiveness Report 2011, showed that Indonesia's transportation infrastructure performance had not shown significant improvement.

As shown in Table 1, Indonesia's transportation infrastructure was superior only to that of the Philippines. The infrastructure ranking at ports was also quite bad compared with other countries and their transportation infrastructure (the Philippines being the exception). A newer version of the Global Competitiveness Report 2017-2018 also does not reveal any appreciable improvement. The infrastructure in Indonesia's ports ranked 72th, far below Singapore (2nd) and Malaysia (20th). The condition of

Indonesia's logistics system has led to a higher cost associated with the distribution of goods. In Indonesia, the cost related to logistics accounts for about 27% of the country's Gross Domestic Product (GDP). When compared to other ASEAN countries such as Singapore (8%), Malaysia (13%), Thailand (20%) and Vietnam (25%), it can be seen that the cost of logistics in Indonesia is significantly higher (Arvis et al., 2014).

Table 1: Rating and Rank for Infrastructure in Asian Countries

2010-2011 and 2017-2018

Country	**Year**	**Roads**	**Railways**	**Ports**	**Airports**	**Electricity**	**Overall**
Indonesia	2011	3.5 (84)	3.6 (56)	3.0 (96)	4.6 (69)	3.6 (97)	3.6 (90)
	2018	4.1 (64)	4.2 (30)	4.0 (72)	4.8 (51)	4.4 (86)	4.1 (68)
Singapore	2011	6.6 (1)	5.8 (6)	6.8 (2)	6.9 (2)	6.7 (9)	6.2 (3)
	2018	6.3 (2)	6.3 (2)	6.7 (2)	6.9 (1)	6.9 (3)	6.4 (2)
Malaysia	2011	5.7 (21)	4.7 (20)	5.6 (19)	5.9 (29)	5.7 (40)	5.0 (27)
	2018	5.3 (23)	5.0 (14)	5.4 (20)	5.7 (21)	5.9 (36)	5.3 (21)
Thailand	2011	5.1 (36)	3.6 (57)	5.0 (43)	5.9 (28)	5.7 (42)	4.8 (46)
	2018	4.3 (59)	2.6 (72)	4.3 (63)	5.2 (39)	5.2 (57)	4.1 (67)
China	2011	4.3 (53)	4.3 (27)	4.3 (67)	4.4 (79)	5.3 (52)	4.4 (50)
	2018	4.6 (42)	4.8 (17)	4.6 (49)	4.9 (45)	5.0 (65)	4.5 (47)
India	2011	3.3 (90)	4.6 (23)	3.9 (83)	4.6 (71)	3.1 (110)	3.5 (85)
	2018	4.3 (55)	4.4 (28)	4.6 (47)	4.6 (61)	4.7 (80)	4.6 (46)
Philippines	2011	2.8 (114)	1.7 (97)	2.8 (131)	3.6 (112)	3.4 (101)	2.9 (104)
	2018	3.1 (104)	1.9 (91)	2.9 (114)	2.9 (124)	(4.2 (92)	3.0 (113)

Note: Rank is in brackets
Source: Global Competitiveness Report, 2010-2011 and 2017-2018

The lack of improvement in logistics performance has contributed to the lack of improvement in its port infrastructure. There are two major types of ports in Indonesia—commercial and non-commercial. Both of these ports function in a similar way: they provide necessary services to a ship that enters the port for loading and unloading cargo as well as for other port activities. However, commercial ports are managed by the state-owned Indonesia Ports Corporation (IPC) and have more complete facilities and larger capacities than non-commercial ports, which are managed by the Technical Operations Unit of the Ministry of Transportation. Between 2007 and 2015, there were virtually no additional ports built, including commercial ports managed by the IPC (Transportation Statistics, Statistics Indonesia, 2015).

In summary, the significant price disparity across regions in Indonesia can be attributed at least in part to its logistic performance, particularly with regard to food and manufactured products. Java is a volcanic island that has quite fertile soil and a fairly advanced irrigation network (Britannica, n.d.), and as a consequence, it has become a major supplier of agricultural products to other regions. The relatively high discrepancy in food prices among regions in Indonesia may arise from inequities in the development of transportation infrastructure. In the eastern provinces of Indonesia the infrastructure is poorly developed compared to that in the western provinces, and that lack of infrastructure hinders accessibility, making it more expensive to distribute goods to those provinces (Giap et al., 2013).

3. Literature Review

A good connectivity system provides broader access to certain regions. Highly accessible regions can often be more competitive because of the fact that it takes less time and energy to transport goods to those regions. Similarly, goods in regions that are not easily accessed are more likely to have higher prices as the transportation of goods to these regions is more expensive and time-consuming. With the development of a more efficient transportation infrastructure, access to those regions will almost certainly become easier and cheaper, leading to less disparity in prices of goods between regions by making the regions more integrated. Since developing a more efficient transportation system may result in more affordable commodities, this policy could have a significant impact on poverty eradication. Lower prices of food commodities lead to an improvement in the welfare of the poor, as shown and proven by Pratikto, Ikhsan, and Mahi (2015). In short, the development of transportation infrastructure in the end may play an important role in alleviating poverty.

Goletti, Ahmed, and Farid (1995) conducted an early study on the effect of transportation infrastructure on price levels in the economy in Bangladesh. They used market integration and the Law of One Price framework and found that the price of rice rose with the increase in the distance between regions. To their empirical model they applied asphalt road density and telecommunication infrastructure as proxies for transportation cost, and these two variables show a negative correlation to price disparity, revealing that more asphalt roads and better telecommunication infrastructure between regions lead to less of a disparity in the price of rice. The result of this is what can be described as achieving a more integrated market.

Using a similar framework to that employed by Goletti, Ahmed, and Farid (1995), Brenton, Portugal-Perez, and Regolo (2014) decided to scale up their study by looking at 150 cities in 13 countries in Africa. They found that greater integration with regard to prices (less of a price disparity) corresponded to countries and cities that had better infrastructure. Road infrastructure improvement led to a reduction in the prices of rice, corn, and sorghum, three staple foods there. Similar results were obtained in India by Donaldson (2010), whose study concentrated more on railroad infrastructure. India's extensive railroad network helps reduce the cost of transporting goods and, as a result, there are smaller price differences between districts there.

Gonzalez, Guasch, and Serebrisky (2007) used an interesting approach when they were investigating how prices are influenced by transportation infrastructure. Using the panel data approach when studying Latin American economies, they found that as transportation infrastructure gets worse, inventory increases. This would imply that an increase in logistics costs can result from a rise in inventory since the delivery of goods is one of the components of inventory. The higher the inventory, the greater the funds the producers have to allocate. It is likely that an increase in the price of goods by the producers follows to offset the amount of funding needed. Marques, Pino, and Horrillo (2014) studied the causes of regional inflation of 98 commodities in Chile using spatial econometrics. Following the work done by Beck, Hubrich, and Marcellino (2006), they found indications that the cost of transportation (based on distance) is also an important factor in explaining inflation in different regions in Chile. Macroeconomic factors such as the unemployment rate, the interest rate, the exchange rate, industrial production, and the cost of labor, however, cannot account for most of the inflation in the commodity sector. Affandi (2011) conducted an empirical study that addressed the importance of transportation infrastructure in relation to persistent inflation in Indonesia. He found that demand is not the only determinant of inflation in Indonesia, but that structural factors are also important, one of which is the cost of transportation. He stated in his conclusion that to solve the problem of persistent inflation in Indonesia, transportation infrastructure should be developed to streamline logistical activity. Moreover, Yudhistira and Sofiyandi (2018) present evidence that the proximity of ports has a positive effect on development in different provinces, and this can raise per capita income, reduce poverty and increase productivity. These last two studies come to a similar conclusion: that the infrastructure that supports trade activities is crucial to regional development. Even when regions are far apart, this problem can be alleviated by an effective logistics system.

The characteristics of a country should be taken into account when developing transportation infrastructure so that greater efficiency can be achieved, economically speaking. Rodrigue, Comtois, and Slack (2006) demonstrated that a combination of land, sea, and air infrastructure should be considered an integrated system that can affect economic development in a positive way. This can have a positive impact on price stabilization, since the supply side is where the expansion of the economy occurs. To achieve this goal in an effective way, though, geographical conditions need to be taken into account to determine what type of transportation infrastructure should be prioritized.

As stated in sections 1 and 2, Indonesia, as an archipelago, should focus more on developing its port infrastructure to effectively integrate the economy and minimize price differences between regions. Because of Indonesia’s unique geography, the focus of this paper is on port infrastructure, but unlike much of the existing literature, we focus on its impact on price disparity, especially regarding food commodities. Studies by Munim and Schramm (2018), Mlambo (2021), Sakalayen, Chen, and Cahoon (2017, 2022) and Syafiq, Sirojuzilam, and Purwoko (2022) have tried to explore the role of port infrastructure on economic and regional development. Munim and Schramm (2018) studied 91 countries and showed that the development of ports infrastructure in developing countries showed relatively high benefits by yielding higher economic growth than in developed ones. In his studies in selected African countries, Mlambo (2021) found that, in order for the African countries to competitively compete in international trade, they needed to invest heavily in developing their port infrastructure.

Table 2: Summary of Literature Review

Author & Year	Country of Analysis	Estimation Method	Main Findings/Outcome	Literature Gaps
Brenton, Portugal-Perez, and Regolo (2014)	150 countries	Panel Data Regression	Road infrastructure improvement could reduce the price of rice, corn, and sorghum.	Only considers road infrastructure as a proxy of transportation cost
Gonzalez, Guasch, and Serebrisky (2007)	Latin America	Panel Data Regression	An increase in logistics costs can result from a rise in inventory since the delivery of goods is one of the components of inventory	Considers roads and rail infrastructure but not ports
Marques, Pino, and Horrillo (2014)	Chile	Panel Data Regression	The cost of transportation (based on distance) is also an important factor in explaining inflation in different regions in Chile	Uses distance as a proxy for transportation cost instead of transportation infrastructure
Affandi (2011)	Indonesia	Time series	Structural factors, such as logistic cost, are important in determining inflation in Indonesia	Needs further empirical evidence regarding logistic costs
Munim and Schramm (2018)	91 countries	Structural Equation Modeling	Developing countries benefit more from investment in port infrastructure	Does not discuss price disparity
Sakalayen, Chen, and Cahoon (2017)	Australia	Qualitative Method, semi-structured interview	Collaboration between regional organizations and regional ports to ensure efficient port performance in the region	Multidiscipline study, but does not consider the role of ports in reducing price disparity between regions
Sakalayen, Chen, and Cahoon (2022)	Australia	Mixed Method	Proposing a placed-based strategic approach in regional port development	Comprehensive study on port development, but does not consider the role of ports in reducing price disparity between regions
Syafiq, Sirojuzilam, Purwoko (2022)	Indonesia	Structural Equation Modelling	Port development has a substantial impact on coastal development through social capital	Does not focus on the role of ports regarding price disparity

A study conducted by Sakalayen, Chen, and Cahoon (2017) had a similar purpose to that of our study. They stated that ports contribute to economic development by facilitating trade and transport, generating employment, and attracting investment. Moreover, they found that ports also play a significant role in creating industry agglomeration in its respective regions, thereby providing increases in productivity. This last statement has an indirect implication to the case of our study in Indonesia. Regions with better port infrastructure not only have lower logistic costs, but by attracting investment and agglomeration of industry, they can provide goods that previously had to be imported from other regions.

A further study by Sakalayen, Chen, and Cahoon (2022) then discusses in more detail how to develop regional ports, and recommends a placed-based strategic approach in developing Australian Regional Ports. This strategy comprehensively considers each area's own characteristics, resources, knowledge base, preferences, and innovation possibilities. Somewhat similar to one of their conclusions, a study on an Indonesian case by Syafiq, Sirojuzilam, Purwoko (2022) concluded that port development is important for respective coastal development in that it increases social capital.

Consequently, we extended the approaches by Goletti, Ahmed, and Farid (1995), Gonzalez, Guasch, and Serebrisky (2007), and Brenton, Portugal-Perez, and Regolo (2014) by incorporating both road and port infrastructures. The insights from Sakalayen, Chen, and Cahoon (2017) and Syafiq, Sirojuzilam, and Purwoko (2022), in the context of increasing regional productivity and development, and Mlambo (2021), in the context of increasing trade competitiveness, will be incorporated in this study's econometric model.

4. Methodology

4.1. Econometric Model

The main idea of this research is that high commodity prices in a particular area are due at least in part to the higher cost of transportation and distribution, the input cost, and low productivity. It is assumed that transportation and input cost increases raise the price of commodities, and that a rise in productivity results in lower prices for those same commodities.

Because the details of the cost of logistics in different parts of Indonesia are poorly known, the ports and roads infrastructure in each province are used as a proxy. It follows that regions with better quality and quantity of transportation infrastructure are more accessible and thus have comparatively low logistics costs. Air infrastructure was not included in the empirical model as there is no balanced panel data of air infrastructure at the provincial level in Indonesia. The empirical model is defined as follows:

$$p_{it}^{j} = a_0 + a_1 cports_{it} + a_2 ncports_{it} + a_3 loadrat_{it} + a_4 grd_{it} + a_5 ws_{it} + a_6 pc_{it} + a_7 fex_{it} + a_8 fp_{it} + a_9 dbbm_{it} + e_{it} \quad (1)$$

Where the subscript represents variables in province *i* at time *t*. Here, p^j is defined as the price index of commodity *j*. The terms *cports* and *ncports* have to do with port infrastructure, where the number of commercial ports is represented by *cports* and the number of non-commercial ports is represented by *ncports*. As has been explained in the second section, the commercial ports have more a developed infrastructure than non-commercial ports, in part because they cover larger areas, allowing them to handle relatively large vessels. Moreover, loading and unloading services at commercial ports are also superior to those at non-commercial ports. It can be assumed, then, that commercial ports outperform non-commercial ports, and this influences cost efficiency in a positive way, since handling time is shorter in commercial ports than in non-commercial ports.

Because transportation activities are concerned with location and time—two variables that cannot be stored (storing is an option for physical commodities)—to achieve cost efficiency, it is important to maximize utility. This maximization can be interpreted as the optimal percentage of a particular usage, for example maximizing the capacity of a shipment, or maximizing transportation use, leading to economies of scale (Rodrigue, Comtois, and Slack., 2006).

In the introduction to this paper, the problem of relatively high logistics costs in Indonesia is due in part to an imbalance in the transport of goods. This is of particular relevance, particularly for shipments within Indonesia that go from west to east. The quantity of goods shipped in an easterly direction is often quite high, so ships achieve a high utility with regard to making shipments. However, after unloading in the east, these ships return to their bases in the west and are at far-from-maximum capacity, perhaps due to low industrialization in the eastern part of the country. The costs incurred from the transport of the ship is not offset by the transport of goods. To prevent such a loss, ships owners charge for deliveries from west to east based on the cost of a round trip, making delivery costs to the east much higher than they would be otherwise. To at least partially solve this particular problem, the *loadrat*, or the ratio of loaded to unloaded commodities in ports, has been made part of the empirical model. It is assumed that provinces that have a higher *loadrat* have a lower cost of access, bringing down price levels.

Although the main thrust of this study is to examine just how port transportation infrastructure influences price stabilization, our model still incorporates land infrastructure. The good road density *(grd)* represents the quality and quantity of road infrastructure and is proxied using *grd* with respect to the total land area, showing quality road coverage in each province. It follows that a higher percentage of road coverage implies lower congestion levels, which in turn makes the flow of goods smoother, lowering both logistics costs and price levels.

The common practice of bribery in weigh station management, which leads to the high-cost economy in Indonesia, has necessitated the inclusion of weigh stations (*ws*) in this study. This phenomenon was also examined by Sumarto, Suryahadi, and Arifianto (2004). A weigh station's main function is to maintain road quality by ensuring that the weight of trucks does not exceed the legal limit. However, it is well known that truck loads often exceed the legal limit for commodities because the truck drivers bribe the officials and are allowed to continue on, even when overloaded. It seems that excessive loads can reduce logistics costs by transporting more goods in one trip; however, this practice can result in diseconomies of scale. When optimal loads are exceeded, trucks travel at slower speeds, and the more trucks there are that exceed their legal load limits, the worse the traffic congestion becomes. So, this leads to an increase in transport time, which in turn increases the logistics costs. These factors lead to higher logistics costs, and the logistics company passes these unofficial costs on to the consumer.

We determined the cost of production (*pc*) by using the Cost of Production and Capital Formation Index from the Food Crops Farmer Terms of

Trade, and the control variables used in this study include *fex*, representing the income allocated for the food expenditure per capita (monthly) and the demand-side of price determinants; *fp*, which is included in the empirical model to represent the productivity of food; and lastly, *dbbm* is the dummy of sudden increases in subsidized-gasoline prices.

The model specification in equation (1) can, however, be subject to the problem of endogeneity. The endogeneity problem may be a result of the inclusion of food expenditure in the model, as an inverse causality between food expenditure and price levels may be likely. Increases in food expenditure often follow food price increases since a household usually allocates more of its income on food to sustain a certain level of consumption. To remedy this problem, the equation (1) specification should be extended into a simultaneous equation, where:

$$fex_{it} = b_0 + b_1 X_{it} + u_{it} \qquad (2)$$

Equation (2) implies that food expenditure would be instrumented by *X*, real income per capita as the Instrument Variable (IV). This approach aims to solve the endogeneity problem (reverse causality of food expenditure and price level) as suggested by Murray (2006).

The data in this particular research was obtained yearly between 2007 - 2015, with a panel from 30 Indonesian provinces. West Sulawesi and North Kalimantan (formerly part of South Sulawesi and East Kalimantan, respectively) were not included since these provinces have not been in existence long, and much of the information on infrastructure is either unavailable or still included in their former provinces' data. The DKI Jakarta province was also excluded due to a lack of farming activity. Because there are no farms, no data is available for the Cost of Production Index of Food. Lastly, the province of Yogyakarta has not been included since this region is the only province with no commercial or non-commercial ports.

The food price index was obtained from the Indonesian Regional Economic Financial Statistics of Bank Indonesia (Bank Indonesia, 2019), and all the data on transportation infrastructure was acquired from the Transportation Statistics of the Ministry of Transportation (Ministry of Transportation Republic of Indonesia, 2019). The Cost of Production and

Capital Formation of Food Crops, output of food production, per capita Real GDP, per capita food expenditure, and minimum wage data were obtained from the Central Statistical Agency of Indonesia (Statistics Indonesia, 2019). Table 3 is a summary of all the variables, except for the dummy gasoline price.

Table 3: Statistical Summary and Variable Attributes

Variable	Attributes	Minimum	Maximum	Standard Deviation	
				Across	Within
Food Price Index	Higher price means lower purchasing power/welfare. Food contributes the most to total household consumption. Higher food prices would detriment the household welfare significantly	98.69	249.02	6.3	32.18
Processed Food Price Index		100.48	229.76	10.51	26.06
Consumer Price Index		100.59	184.29	4.11	21.36
Commercial Ports	More commercial ports means better access and connectivity, especially in terms of logistics.	1	12	2.75	0
Non-Commercial Ports	Non-commercial ports have the same role as commercial ports, though with less capacity than the commercial ports	1	70	18.47	0.62
Load-Unload Ratio	Higher load-to-unload ratio means that the region has relatively high productivity, thus logistic costs are assumed to be lower and more trade competitive	0	31.03	1.92	2.17
Good Road Density	Better road condition and coverage means better access and connectivity	0.01	0.69	0.14	0.04
Weigh Stations	Proxy variables for rent-seeking behavior in logistics	1	21	4.91	0.67
Food Expenditure	Proxy for demand side of food	156,843	551,557	47,879	62,013
Food Production	Proxy for supply side of food	716	59,261	12,676	1,426
Production Cost of Food	Proxy for cost of food production	98.42	161.63	6.94	12.11

Source: Authors' Calculations

4.2. Empirical Estimation

The panel data regression method was used at the provincial level in Indonesia to address the problem of price disparity between different provinces in Indonesia. Fixed Effect (FE) was not employed in the estimation of equation (1) since the variable of interest is time-invariant or varies very little within the subjects (see Table 3). Kittel and Winner (2005) state that cross-sectional variants would be eliminated by the FE specification from its estimation. Clark and Linzer (2015) and de Haas and van Lelyveld (2006*)* corroborated these findings and have stated that, for time-invariant or entity-variance variables, a more proper panel data regression is Random Effect (RE) regression.

As indicated by the econometric model specification, equation (1) is subject to an endogeneity problem. This problem can be dealt with in a number of ways, one of which is the Two-Stage Least Squares method, or 2SLS (Murray, 2006). To employ 2SLS, the Instrument Variables (IVs) for the food expenditure have to first be specified. Levitt (1997, 2002) and Murray (2006) have shown that the IV that is included should be robust and does not have the same problem of the instrumented variable, since the inclusion of a weak or invalid instrument could be a case of the cure being worse than the disease. Following Levitt (1997, 2002) and Murray (2006), we used per capita Real GDP as a substitute for per capita real income. Price movement is excluded by Real GDP by definition; therefore, it is believed that this instrument will not experience the same problems as food expenditure in terms of correlation with food prices[4]. Lastly, for the purpose of robustness of results, the Hausman-Taylor (H-T) method has also been employed to address problems in the model specification. Firstly, the H-T procedure makes it possible to estimate equation (1) using the FE assumption in some of the regressors, while still including the time-invariant variable, which is the commercial port. Secondly, by employing this H-T estimation, the endogeneity problem of food expenditure is also addressed, since the estimator allows us to use the aforementioned instruments (Baltagi, 2001)

[4] Murray (2006) felt that is was better to make an argument based on intuition with regard to a valid instrument variable than make no argument at all. This intuition can and should be tested. One practical way to test it is by running reduced form regressions making the instrumental variable the explanatory variable and making either the dependent variable of interest or the troublesome explanatory variable the dependent variable. In Appendix A we show the results of this method, and those results strengthen the intuitive argument above.

5. Discussion

The empirical results based on equation (1) and (2) are addressed in this section. All variables in the empirical model are in natural logarithm, except for the dummy gasolina price and good road density. To analyze the robustness, a regression of equation (1) was carried out, with the endogenous variables in the PLS and RE methods being the processed food price index (including tobacco and beverages) and the consumer price index (CPI). As stated in the empirical estimation section, the FE method was not employed in the regression results, since port infrastructure in Indonesia—especially the strategic ports (commercial ports) between 2007 and 2015—did not change in total or in respective provinces (time-invariant), and employing the FE method gave no results for a strategic port regression. Nonetheless, we also employed the H-T method to address both the endogeneity problem from omitted variable bias, while still including the time-invariant variable, strategic port infrastructure.

The results of the estimation are shown in Table 4 and 5. It can be seen that no significant differences exist between the PLS, RE, 2SLS, and H-T estimation results, and there is also consistency in the coefficients of all variables. A strong correlation between the number of commercial ports and food prices can be seen in all regressions, confirming the idea that the development of infrastructure is an important factor in determining food prices in Indonesia.

Commercial ports are shown in all regressions to cause a lowering of prices, the food price index being impacted the most. It is interesting to note that non-commercial ports do not contribute to lower prices in general, meaning that the building of commercial ports is preferable to the building of non-commercial ones. As mentioned above, commercial ports are physically larger than non-commercial ports and can accommodate larger vessels. This, of course, implies that the use of large vessels is more economical than smaller vessels since larger vessels can ship more commodities; therefore, the logistics costs for commercial ports are lower than the logistics costs for non-commercial ports, and that leads to lower price levels. In the development of port transportation infrastructure, land transportation infrastructure also has to be considered, since it is what connects the ports to the markets. Our results show that the impact of good road density is not significant in almost all regressions. However, the

Hausman-Taylor estimation produces a negative correlation that is statistically significant. These results indicate that, though the main problems of Indonesian logistics have to do with port infrastructure, the availability of good roads is also necessary. The proximity of ports to markets, combined with the condition of roads may be a better determinant in decreasing logistics costs, as indicated by Yudhistira and Sofiyandi (2018).

Table 4: Regression Results on Pooled and Random Effect

	Pooled Regression			*Random Effect Regression*		
	Food	Processed Food	CPI	Food	Processed Food	CPI
	(1)	(2)	(3)	(4)	(5)	(6)
Commercial Ports	-0.053*** (0.013)	-0.014 (0.014)	-0.017* (0.010)	-0.047** (0.021)	-0.018 (0.035)	-0.015 (0.021)
Non-Commercial Ports	0.020*** (0.007)	0.007 (0.007)	0.015** (0.005)	0.022** (0.010)	0.004 (0.021)	0.017 (0.013)
Load-Unload Ratio	-0.024** (0.010)	-0.024** (0.010)	-0.016** (0.007)	-0.011 (0.011)	-0.010 (0.012)	-0.002 (0.008)
Good Road Density	-0.029 (0.038)	-0.048 (0.038)	-0.075** (0.029)	0.044 (0.070)	0.127 (0.135)	0.003 (0.062)
Weigh Stations	0.042*** (0.013)	-0.011 (0.015)	0.016 (0.010)	0.014 (0.017)	-0.051** (0.024)	-0.003 (0.019)
Production Cost of Food	1.104*** (0.072)	1.020*** (0.098)	0.928*** (0.064)	1.371*** (0.086)	1.300*** (0.171)	1.094*** (0.122)
Food Expenditure	0.360*** (0.033)	0.266*** (0.042)	0.224*** (0.028)	0.307*** (0.038)	0.188*** (0.073)	0.198*** (0.049)
Food Production	-0.025** (0.010)	-0.001 (0.013)	-0.018** (0.008)	-0.015 (0.016)	0.035 (0.032)	-0.010 (0.019)
Dummy Gasoline Price	0.076*** (0.013)	0.047*** (0.014)	0.063*** (0.010)	0.068*** (0.010)	0.036*** (0.006)	0.058*** (0.004)
Constant	-4.648*** (0.267)	-3.299*** (0.294)	-2.275*** (0.193)	-5.351*** (0.204)	-3.959*** (0.375)	-2.827*** (0.152)
R-squared	0.778	0.702	0.784	0.769	0.659	0.774
F-stat	145.1***	104.8***	159.36***	-	-	-
Wald	-	-	-	1630***	506.0***	756.0***
n	270	270	270	270	270	270

Numbers in brackets are *standard error*; Significant at α = *10%, **5%, ***1%
Source: Authors' calculations

Problems with logistics services in Indonesia are not solely due to the physical transportation infrastructure, but the low utility of shipments is also a factor. If ships achieve maximum capacity, the cost of logistics services can be quite low, and in Indonesia, shipments from the western part of the country to the eastern islands are often at full capacity. As mentioned earlier, when ships sail back to the western part of the country, the amount of commodities/goods transported from the eastern part of Indonesia is comparatively low, and this phenomenon is called *empty backhaul*. When this is the case, logistics services charge more for shipments because the cost to return from the east with ships at less than full capacity is calculated in. This problem can be seen in our empirical results. Lower price levels correspond to higher load-to-unload ratios, and the provinces with these higher ratios are mainly located in the western part of Indonesia.

Table 5: Regression Results on 2SLS and Hausman-Taylor

Independent Variable	Dependent Variable: Food Price Index			
	2SLS; IV: Real GDP per Capita			Hausman-Taylor
	(7)	(8)	(9)	(10)
Commercial Ports	-0.066*** (0.020)	-0.082*** (0.021)	-0.065*** (0.015)	-0.182* (0.107)
Non-Commercial Ports	0.006 (0.009)	0.006 (0.009)	0.021*** (0.007)	-0.066 (0.043)
Load-Unload Ratio		-0.031** (0.016)	-0.026*** (0.010)	-0.008 (0.017)
Good Road Density		0.103 (0.076)	-0.018 (0.041)	-0.210*** (0.031)
Weigh Stations		0.047*** (0.016)	0.053*** (0.015)	0.027 (0.031)
Food Production			-0.024** (0.01)	
Food Production Cost			0.966*** (0.115)	
Dummy Gasoline Price			0.080*** (0.013)	
Food Expenditure	0.420*** (0.088)	0.526*** (0.087)	0.451*** (0.064)	0.822*** (0.032)
Constant	-0.185 (1.105)	-1.557 (1.101)	-5.142*** (0.431)	-5.324*** (0.479)
R squared	0.447	0.657	0.773	-
F-stat	8.13***	8.00***	136.2***	Wald: 864***
n	270	270	270	270

Numbers in brackets are *standard error*; Significant at α = *10%, **5%, ***1%
Source: Authors' calculations

The results also indicate an imbalance in the development of industry in Indonesia. The eastern Indonesia provinces such as Nusa Tenggara, Sulawesi, Maluku and Papua do not exhibit the industrial development that the western provinces do. These results can be seen as a legitimate reason for policymakers to develop transportation infrastructure in eastern Indonesia, thereby facilitating accessibility in these regions and encouraging investment. Rising investment would be followed by increases in industrialization, more balanced productivity, and increased availability of goods in the east of the country.

In summary, the number of weigh stations shows a positive correlation at all price levels. This seems to be evidence of rent-seeking behavior within the weigh-station management. Sumarto, Suryahadi, and Arifianto (2004) detected the phenomenon of bribery in weigh station management in Indonesia directly. They found that between two and seven percent of the total commodity value was charged on trucks delivering goods from Kabanjahe, North Sumatera to Jakarta. This is in line with our own results, which showed elasticity of weigh stations on prices ranging from two to eight per cent. This result does not imply that there would be lower distribution costs if the weigh stations were shut down, but it has more to do with the efficacy of implementing the rules and regulations.

Looking at the results of our research regarding infrastructure variables, there is a good evidence that port infrastructure and supporting infrastructures are essential in price formation. An increase in the flow of good leads to a decrease in the cost of logistics. Bad road conditions, especially those that connect the markets and the ports, can slow the flow of goods. In addition to contributing to distribution costs, Limao and Venables (2001) and Shirley and Winston (2004) showed that bad roads also lead to a rise in inventory costs.

We also found a positive relationship between the cost of production of food commodities and food prices; however, the results indicate that food price formation includes a markup factor (Kalecki, 1971). A one-per-cent increase in food production costs often leads to a rise in food prices of around 0.8 per cent. In our model, other food price determinants may act as markup factors. According to Kalecki (1971), one determinant of markup is overhead cost, such as the cost of distribution. In accordance with our findings, developing port infrastructure, managing land infrastructure better, and developing the industry sector in a more balanced way could lead to lower distribution costs throughout Indonesia, keeping the markup low and resulting in more stable consumer prices.

A sudden increase in the price of subsidized gasoline can cause a general increase in prices across the board. Even though subsidized gasoline does not directly contribute to the cost of production (industry does not benefit from fuel subsidies), our results show that it may still increase inflation and distribution costs. Furthermore, income allocation for food can also affect prices, and increasing the amount of money spent on food puts food, processed food, and consumer price indices under strong inflationary pressure.

Analysis of food production implies that lower food prices result from increases in food production. Warr (2011), in his study on Indonesia's policy on rice self-sufficiency, came to the same conclusion. He stated that Indonesia should pursue policies that increase the productivity of domestic rice rather than put restrictions on imports. In our study, it is argued that port infrastructure is an important factor in ensuring efficient food distribution throughout the country. The quality and quantity of land varies greatly from province to province, and those regions that have larger areas of more fertile land have a decided advantage when it comes to producing food. The use of technology in food agriculture should be promoted by the Indonesian government in these particular areas. An increase in productivity could lead to an excess in the food supply, which could be used to trade with other districts. In the end, the quality of transportation infrastructure determines how big the inter-regional price disparity is. A more equal distribution and higher quality of transportation infrastructure, and in particular port infrastructure, would lower logistics costs and, as a consequence also lower the disparity in food prices between regions.

In addition to these, our study also implies that the development of ports in different regions depends greatly on the region's respective characteristics. This is in line with the study by Sakalayen, Chen, and Cahoon (2022) where the strategy for regional port development should be embedded in each region's resources and capabilities, making them more sustainable and allowing them to gain a competitive advantage. A similar conclusion was also made by Syafiq, Sirojuzilam, and Purwoko (2022) where a port's sustainability had a substantial effect on coastal development by increasing the respective area's social capital. Further study is needed, however, in the Indonesian case to look into details as to what a suitable strategy in developing its regional ports would be. In this regard, a similar study by Sakalayen, Chen, and Cahoon (2022) can be applied to the Indonesian case for future research, since its regions' characteristics are more varied.

5. Conclusion

Upon examination of panel data from 2007 to 2015 at the province level in Indonesia, it is apparent that an increase in commercial port availability could solve the price discrepancy problem between provinces in Indonesia. It has been shown that in terms of lowering prices, non-commercial ports are not as effective as commercial ports, simply because of the superior infrastructure in commercial ports, both in physical and soft infrastructure. The physical infrastructure in commercial ports is important since large ports can service large vessels, and the logistics costs involved with the use of large ships are usually more competitive, since the ships can handle large amounts of cargo. Because of that, economies of scale for large vessels are better than for smaller ones.

The flow of goods over land is another important factor in price formation that relates to logistics activities. Traffic congestion and a slower flow of goods caused by overloaded trucks could be caused by the rent-seeking behavior in weigh station management. Higher prices would likely follow, since the cost of a bribe is likely to be included in a producer's markup pricing. It is also important in Indonesia to have a more balanced industrial development. The imbalance in production between regions in Indonesia can lead to empty backhaul in logistics activities. If there were goods or commodities being transported from one particular region to another, this problem could be solved. By increasing the cargo load in both directions, there would be more efficient logistics activities and, therefore, lower price levels, particularly for food.

The statistical results seem to imply that road infrastructure may play an important role in lowering food price disparity, though its role is not as important as that of port infrastructure. Given that we use road networks in each province to approximate the quality of road infrastructure, we have to be cautious in making policy analysis based on those results. Since we use commercial and non-commercial ports to represent logistic maritime infrastructure, it might be better to use the road network conditions from main ports to market centers as the proxy for logistic road infrastructure, which can serve as a future research direction and lead to robustness in terms of the role of logistic road infrastructure in lowering prices.

6. Policy Implications

In general, this research has provided empirical evidence that regional food prices in Indonesia are dependent on the transport/logistics costs. Because of this, making a price-control policy for food commodities in Indonesia has proven to be quite a challenge. The price-control policy from the demand side is ineffective, since food price shocks originate from structural shocks. A concerted price-control policy is needed where policy on the supply-side addresses a specific structural economic problem. In Indonesia, one such structural problem has to do with domestic infrastructure. A structural bottleneck and a higher cost of distribution is caused by the lack of development in the transportation sector. This, in turn, would likely lead to higher prices for consumers.

The results of this study show that the main challenge in price control policy, especially for food commodities in Indonesia, is geographical in nature, and Indonesia is an archipelagic country. The high price disparity between regions, especially between the east and west of Indonesia, arise from an inefficient logistics system that is not supported by sufficient port infrastructure. Therefore, this study's main contribution is to show that in the Indonesian economy, which relies heavily on maritime connectivity, an efficient logistics system with regard to port infrastructure is essential in uniting the Indonesian markets and also lowering price disparity.

An efficient logistics system, especially as regards port infrastructure, not only plays an important role in uniting the domestic market, but in increasing Indonesian competitiveness in terms of world trade. Because of this, further research is needed with regard to logistics performance in international trade—especially in port transportation—which also can be of value to other countries that are not archipelagic

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