On the revision of detecting learning-by-exporting: empirical evidence from small- and medium-sized enterprises in Vietnam

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Abstract

This study aims to identify the role of exports in improving the productivity of small- and medium-sized enterprises (SMEs) in Vietnam. By applying the propensity score matching method, we exploit the firm-level panel dataset from the Vietnam SME Survey between 2009 and 2014. This remarkable period occurred two years after Vietnam's accession to the World Trade Organization. Hence, for the first time, the learning-by-exporting hypothesis was tested for a case study of SMEs in developing countries in the context of international trade integration, such as Vietnam. This paper shows that SMEs in Vietnam could improve their productivity when exporting during the studied period. We also find that exports have a significant impact on the productivity of SMEs in non-municipal areas of Vietnam. Based on these findings, policy recommendations are withdrawn for stimulating the productivity of SMEs in developing countries. In particular, SMEs in non-municipal provinces might need more favorable policies to boost export activities.

Keywords: Exporting, Total factor productivity, Learning-by-exporting, Vietnam, Small- and medium-sized enterprises

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1. Introduction

Small- and medium-sized enterprises (SMEs) in developing countries like Vietnam and other developed countries have played a significant role in the economy. According to the Ministry of Planning and Investment of Vietnam, in 2020, SMEs accounted for about 97% of the number of businesses in Vietnam. Yearly, SMEs contribute up to 40% of national income (GDP), 30% of the government budget, and 33% of industrial production value, and create jobs for 50% of the labor force (Hai, 2019). According to the OECD (2000), SMEs create about 60-70% of total workers on average in countries at all levels of development. In the context of globalization, there are many challenges that SMEs have to face when entering the global market (Melitz, 2003), and the capacity of SMEs is fewer than larger-sized firms to adopt new regulations from the new markets. However, SMEs have more opportunities to gain benefits from the international market since they are more flexible in customizing and differentiating their products, hence, making it easier to adapt to the requirements of foreign markets. Therefore, it is interesting to understand whether integration into global trade, such as export, could improve the productivity of SMEs, especially in a developing country like Vietnam. This paper aims to identify the role of exporting in productivity improvement for the case study of SMEs in Vietnam in the context of its global trade integration (from 2009 to 2014) after the country entered the World Trade Organization (WTO) in 2007.

In terms of exports, notwithstanding the COVID-19 pandemic, Vietnam has still beheld some good results for which SMEs can be considered a key driver. Firstly, there have been noticeable increases in the number of SMEs joining direct export each year. Secondly, their contribution makes up a large proportion, nearly 30% of total Vietnamese exports (Binh and Phuong, 2021). Thirdly, while e-commerce has been a vital trend that facilitates trade flows not only in domestic markets but also among nations, export is now becoming more possible for SMEs in Vietnam to apply digitalization and enhance their competency. In addition, Vietnam is stated to be one of the best performers in terms of digital transformation in Southeast Asia due to the phenomenal growth rate of e-commerce, reaching 34% per year and higher than the average in this area (Google, Temasek and Bain and Company, 2020). As a result, around 32% of SMEs in Vietnam succeeded in establishing business relationships with foreign partners via online connections (GSO, 2021).

For ages, Vietnam has applied several policies supporting firms to participate in international trade such as providing a level playing field for private, state-owned, and FDI firms, tying the communication between the government and intermediate institutions, or increasing enterprises' level of competitiveness. Nonetheless, the results still fall short of prior expectations and need a better adjustment (Wiemann *et al.*, 2006; Kyburz and Huong, 2016; Clarke *et al.*, 2017). Therefore, findings in detecting the learning-by-exporting effects can hint at whether export markets are a channel of productivity growth for Vietnamese firms, especially SMEs, in different contexts. Based on such evidence, policy options for boosting the involvement in the global trade of the SME sector can be better warranted.

In recent decades, economists have paid more attention to the impacts of export activities on a firm's productivity, such as learning-by-exporting (De Loeker, 2007; Vanbiesebroeck, 2005; Bigsten *et al.*, 2004; Baldwin and Gu, 2004; Girma *et al.*, 2004). In the context of Vietnam, by examining this hypothesis, a few studies find that exporting leads to within-firm higher productivity. Whilst some others reveal an opposite result (Hiep and Ohta, 2009; Huong *et al.*, 2012; Tra *et al.*, 2014). Albeit the mixed findings are not uncommon, which still leaves a gap in the literature for SMEs' export and productivity improvement, further investigation into this causality is still needed.

In short, little empirical evidence is available for learning-by-exporting for SMEs in developing countries such as Vietnam. More interestingly, there is an open discussion on the productivity gap between exporting and non-exporting SMEs across regions such as between municipalities and non-municipalities. Hence, this paper focuses on testing the learning-by-exporting hypothesis by exploiting firm-level panel data constructed from the Vietnam SME Survey between 2009 and 2014 in the two different spatial management of the local governments. This studied period would give a better context for the global trade integration of the country since its WTO accession was in 2007. We employ the propensity score matching method in which exporting in the previous year is regarded as the treatment. There is strong evidence that SMEs in Vietnam could improve their productivity when exporting. Apart from that, exporting induces stronger impacts on SMEs' productivity in the non-municipal areas of Vietnam than on the productivity of their counterparts in the municipalities. For the first time, such results are found in the case study of SMEs in developing countries like Vietnam in the context of deeper international trade integration.

The remainder of this paper is organized as follows. Section 2 discusses the existing theories together with related empirical research. Section 3 describes the dataset. Section 4 represents the research methodology. Section 5 analyzes the research results. Finally, section 6 concludes the paper and provides some suggestions for trade policymakers.

2. Literature review

Firm-level data from many countries have indicated the superiority of exporters over non-exporters with respect to firm characteristics such as size or productivity. Accordingly, scholars usually suggest testing two common theories for interpreting such findings: (i) the self-selection hypothesis and (ii) the learning-by-exporting hypothesis. Both approaches consider the causation between firm productivity and export behaviors; however, they observe this from two opposing directions.

Regarding the self-selection hypothesis, existing studies discuss that only productive firms in an industry are able to enter foreign markets due to the presence of entry sunk costs (Robert and Tybout, 1997; Bernard and Wagner, 1997; Clerides *et al.*, 1998; Bernard and Jensen, 2003; Melitz, 2003).

On the other hand, the learning-by-exporting hypothesis argues that export makes firms more productive through a learning process (Vanbiesebroeck, 2005; De Loecker, 2007).

Learning-by-exporting refers to the mechanism whereby firms improve their performance, i.e., productivity, after entering export markets (De Loecker, 2013). This is because entry into export markets can improve access to information on the best managerial and marketing practices, new technologies, and exposure to competition (Clerides *et al.*, 1998). Essentially, exporters can learn both directly, via the seller-buyer relationships, and indirectly, via the increased competition from foreign manufacturers, by improving their product quality or shipment size and undertaking specific investments in modern technologies or marketing campaigns (De Loecker, 2013).

As for the learning-by-exporting hypothesis, evidence is found in some developed countries, such as Italy (Castellani, 2002), Canada (Baldwin and Gu, 2004), England (Girma *et al.*, 2004; Greenaway and Kneller, 2008), Japan (Kimura and Kiyota, 2006), or France (Bellone *et al.*, 2006); and in some developing countries, such as Taiwan (Aw *et al.*, 2000), Indonesia (Blalock and Gertler, 2004), Chile (Alvarez and Lopez, 2005), and Turkey (Yasar and Rejesus, 2005). In contrast, no significant impact is observed in German (Bernard and Wagner, 1997; Arnold and Hussinger, 2005), the United States (Bernard and Jensen, 1999), Spain (Delgado *et al.*, 2002; Farinas and Martin-Marcos, 2007), Ireland (Ruane and Sutherland, 2005), Sweden (Greenaway *et al.*, 2005), and Morocco (Fafchamps and Gubert, 2007).

In the case of Vietnam, some empirical studies investigate the learning-by-exporting effect. Hiep and Ohta (2009) exploited the firm-level data from the World Bank Enterprise Survey 2005. They found strong evidence that a firm's export status positively impacts its future productivity. Another study by Huong *et al.* (2012) detected the same causality between export and productivity but used a different dataset constructed from the Vietnam SME Survey for 2005-2009. Essentially, the authors distinguished three components of TFP, precisely technical progress, technical efficiency, and scale efficiency. Thus, they could observe the causal effect on each firm decision to enter export markets. However, contrary to Hiep and Ohta (2009), they found no evidence suggesting the existence of the learning effect among Vietnamese firms via adopting a GMM/IV estimation. It might be because the time series (2005-2009) used by Huong *et al.* (2012) did not fully reflect the context of global trade integration since Vietnam joined WTO in 2007. In contrast, a significant impact of export decisions by firms on their productivity enhancement was also found by Tra *et al.* (2014) with the investigation of the World Bank enterprise survey for 2002-2008. Long and Tam (2018) updated their dataset to the studied period between 2002 to 2012, but the authors only looked at labor productivity, not the TFP. The evidence on such causality between export and productivity improvement remains modest as these existing studies ignore the differences in regional policies in trade for SMEs.

3. Data description

The data for our analysis are retrieved from the Vietnam SME Survey that are collected biennially from 2005 to 2015. These data are jointly managed by the Institute of Labor Science and Social Affairs (ILSSA), the Central Institute for Economic Management (CIEM), the Development Economics Research Group (DERG) at the University of Copenhagen, and

UNU-WIDER. This is a rich source of microdata of more than 2,500 enterprises each round, surveyed for nine provinces of Vietnam and covering all major manufacturing sectors such as food and beverage, wood, fabricated metal products, and rubber. As the survey contains vital details on firms' export status, added value, capital, labor, material, year of founding, sector, and location, we can construct a panel data set for testing the learning-by-exporting hypothesis. After removing missing values and merging the three rounds together, our database was created containing 1,293 firms from 2009 to 2014 which induces a consistent panel data set for our estimation. The data in 2014 are the last data set for the Vietnam SME Survey collected in 2015. In addition, we performed some descriptive statistics to guarantee that this sample can suitably represent SMEs in Vietnam.

Table 1. Sample structure by firm size (2009-2014)

Firm size	Freq.	Percent	Cum. Percent
Micro	995	76.95	76.95
Small	284	21.96	98.91
Medium	14	1.08	100.00
Total	1293	100.00	

Notes: Firm size is defined based on Decree No. 80/2021/ND-CP issued on 26 August 2021. The sample structure by firm size in each year from 2009-2014 was described in Appendix 1.

Source: Authors' calculation

As shown in Table 1, medium-sized firms accounted for just 1.08%. In comparison, micro and small firms dominated the dataset with 76.95% and 21.96%, respectively, accumulating at 98.91% and close to the Ministry of Planning and Investment estimates in 2014. The majority of firms in the sample remained non-exporters from 2009 to 2014. However, the fraction of exporters began to rise in 2013 and hit 3.48% in 2014 (Table 2). This may reflect weak ties to the global markets of SMEs in Vietnam and how the economic recovery in 2013 assisted in their export activities. This fact suggests a deeper analysis of whether the SME exporters gain more productivity compared to the non-exporters, then whether the government should implement policies to support exporting activities to stimulate the productivity of SMEs.

Table 2. Firms' export status (from 2009 to 2014)

Export status	2009	2010	2011	2012	2013	2014
Non-exporter	1260	1259	1260	1260	1253	1248
	97.45%	97.37%	97.45%	97.45%	96.90%	96.52%
Exporter	33	34	33	33	40	45
	2.55%	2.63%	2.55%	2.55%	3.10%	3.48%
Total	1293	1293	1293	1293	1293	1293

Source: Vietnamese SMEs firm-level data

4. Research methodology

The common method in the existing literature to detect learning-by-exporting is the treatment estimation approach, in which exporting is considered a treatment that divides firms into two separate groups: exporters (treatment group) and non-exporters (control group) (Greenaway and Yu, 2004; Yasar and Rejesus, 2005; De Loecker, 2007). The average difference in productivity between enterprises in these two groups is the effects of exporting (treatment effect). The methodology is popularly applied in recent studies because it can handle possible technical problems, i.e., endogeneity, inherent in the estimation process using a microdata panel (Cameron and Trivedi, 2005). Hence, in this paper, we closely follow this framework. The other method is to insert exporting as one of the factors in the equation of company productivity (Blalock and Gertler, 2004). However, this method did not look at the probability of whether non-exports could have gained more productivity if they exported.

We match exporters, the so-called treated, with the untreated group of non-exporters, conditional on observable firm characteristics. Accordingly, the average effect of export participation can be defined as follows:

$$ATET = E(Y_{it}^1 - Y_{it}^0 \mid D_{it-1} = 1) = E(Y_{it}^1 \mid D_{it-1} = 1) - E(Y_{it}^0 \mid D_{it-1} = 1) \tag{1}$$

where $ATET$ means the average treatment effect on treated which could be estimated by the causal estimand; Y_{it} denotes the productivity of firm i at time t that is casually affected by its export status at time t - 1, and is estimated by the natural logarithm of total factor productivity following the LP approach (Levinsohn and Petrin, 2003); Y_{it}^1 is the productivity of firm i at time t if it exported at time t - 1 and Y_{it}^0 otherwise; D_{it-1} is a binary indicator of export status, i.e. the treatment, equal to 1 if firm i exported at time t - 1 and 0 otherwise. As the term $E(D_{it-1}=1)$ is a counterfactual, it is unobservable for Y_{it}^0 and needs to be replaced by $E(D_{it-1}=0)$, hiring the propensity-score matching of Rosenbaum and Rubin (1983). The propensity score matching (PSM) method could be more appropriate for this dataset compared to the difference in difference method (De Loecker, 2013) when there is missing information about the starting or ending time of export activities because the PSM method only requires the matching between the exporters and the non-exporters.

Equation (1) is rewritten as:

$$ATET = E(Y_{it}^1 - Y_{it}^0 \mid p(x), D_{it-1} = 1) = E(Y_{it}^1 \mid p(x), D_{it-1} = 1) - E(Y_{it}^0 \mid p(x), D_{it-1} = 0). \tag{2}$$

In this paper, we estimate Equation (2) by applying the propensity score matching method. We adopt procedure *teffects psmatch*, supported by Stata, to create the matched sample and measure the causal effect of exporting on firm productivity. Checking for the balancing and overlap assumption, we then employ *tebalance* and *teffects overlap*, respectively. First, we construct a new sample that includes exporters and their compatible group of non-exporters, known as the matched sample, to compute propensity scores. A propensity score is the conditional probability $p(x)$ of receiving the treatment at time t, i.e., exporting, given specific firm characteristics, so-called the pre-treatment variables.

Following previous studies, we include firm age, size, sector, region, and capital-labor ratio in the propensity score equations (Hiep and Ohta, 2009; Tra *et al.*, 2014). Essentially, those time-variants are one-year-lagged variables. This allows us to control reversed effects that may cause the estimate of export likelihood biased. Besides, we carefully examined the overlap assumption, claiming that each firm has a positive probability of receiving each treatment level. We also checked for the balancing of pre-treatment characteristics, i.e., the condition of whether an export decision of a firm is random given its estimated propensity score. The results of those sub-steps gave us a reliable matching for estimating Equation (2) in the second step.

We use different sets of pre-treatment variables to compute the propensity scores and organize the original database into sub-samples considering whether the firm is located in a municipality before the final step. We then include year dummies in those sets to control year effects using a panel data set. Detailed variable measurement is presented in Table 3 below.

Table 3. Variable measurement

	Variable	**Mean**	**Measurement**
Total factor productivity	TFP	0.11	The natural logarithm of total factor productivity. We use output, capital, labor, and intermediate inputs data to measure the within-firm TFP, using the Levinsohn and Petrin (2003) technique or the LP method. The LP method suggests estimating the Cobb-Douglas production function, employing intermediate inputs as a proxy to control the unobserved productivity shocks. Output can take the form of revenue or value added. In this paper, we use the latter.
Value added	VA	-0.94	The natural logarithm of total revenue is subtracted by total purchases of raw materials, intermediate inputs, and energy costs, i.e., water and electricity.
Capital	K	0.12	The natural logarithm of the total value of physical assets.
Labor	L	1.75	The natural logarithm of the total number of regular full-time laborers.
Intermediate inputs	M	-3.24	The natural logarithm of the total value of raw materials.
Treatment variable			
Export status	E	0.27	A dummy receiving 1 given a firm is an exporter, and 0 otherwise.
Pre-treatment variable			
Age	Age	15.76	The number of years since a firm was established.
Capital-labor ratio	K/L	0.41	The ratio of a firm's capital to its labor.
Size	Size	0.99	A dummy receives 1 if a firm is medium-sized and 0 otherwise.

Table 3. Variable measurement (*continued*)

	Variable	Mean	Measurement
Sector	Sector	0.13	A dummy receiving 1 given a firm works in a high-technology industry; and 0 given it works in a low-technology industry. Industry classification is based on the suggestion by OECD (2011), using R&D intensity as the key criterion.
Urban	Urban	0.90	A dummy receiving 1 given a firm is located in an urban area in Vietnam, and 0 otherwise. Whether an area, rural or urban, is determined regarding Resolution No.1210/2016/UBTVQH13 (The National Assembly Standing Committee, 2016).
Year Dummies	Year		[included]
A criterion to construct two separate sub-samples			
Municipality	Muni	0.54	A dummy receiving 1 given a firm is positioned in a municipality of Vietnam, i.e., Hanoi, Ho Chi Minh City, Da Nang, Can Tho, or Hai Phong, and 0 otherwise.
Municipality	Muni	0.54	A dummy receiving 1 given a firm is positioned in a municipality of Vietnam, i.e., Hanoi, Ho Chi Minh City, Da Nang, Can Tho, or Hai Phong, and 0 otherwise.

Source: Authors' calculation

5. Estimation results

Table 4 shows the estimation results of Equation (2). We have significantly positive coefficients regardless of the distinct specifications mentioned in the preceding section.

The result revealed in Column (1) is from the specification that does not apply any pretreatment characteristic to control the regional factor during propensity-score computation. Accordingly, exporters within a given sector, i.e., high- or low-technology industry, have significantly improved productivity compared to non-exporters from 2009 to 2014. A similar trend is observed when we insert a location dummy in the first step, capturing whether a firm is located in the urban (1) or the rural (0) areas.

Next, we construct two separate sub-samples from the original one: (a) firms in municipalities and (b) firms in non-municipalities. The results from estimating Equation (2), using this sub-sample (a) with and without the control for location effect, are shown in Columns (3) and (4), respectively. Such figures still provide significant evidence for the positive influence of export participation by firms on their productivity advancement, yet they are almost equal to each other. Similar procedures run by adopting sub-sample (b) derive different results, denoted in Columns (5) and (6). Likewise, we capture positive evidence that the selection into exporting can increase firms' productivity. In short, all the outcomes are significant, confirming that the export activity stimulates firm-level TFP.

Table 4. Estimated effects of export on firm productivity

TFP	Full sample		Municipality		Non-Municipality	
	(1)	(2)	(3)	(4)	(5)	(6)
ATET	0.083***	0.079***	0.076***	0.076***	0.099**	0.111**
	(5.49)	(5.26)	(4.64)	(4.64)	(2.61)	(2.66)
Urban controlled		Yes		Yes		Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5172	5172	2812	2812	2360	2360

Notes: t-statistics in parentheses; + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. We include vce(iid) in all estimations since the default robust standard errors for the estimated ATET require viable matches for both treated and control subjects (Abadie and Imbens, 2016). (1), (3), and (5) are pre-treatment variables consisting of firm age, size, sector, capital-labor ratio, and year dummies; (2), (4), and (6): the control variable urban is further added into this set. Vietnam has five centrally controlled municipalities: Hanoi, Ho Chi Minh City, Can Tho, Da Nang, and Hai Phong.

Source: Authors' calculation

In general, our findings in Table 4 give strong evidence supporting the learning-by-exporting effect for the case study of SMEs in Vietnam in the context of deeper international integration. Table 4 indicates that the TFP obtained by the exporting SMEs is higher than the non-exporting SMEs, from about 0.08% to 0.1% between 2009 and 2014 in Vietnam. More particularly, export to foreign markets is a key driver of an exporting SME in gaining more productivity compared to a non-exporting SME after the accession of Vietnam to the WTO. In essence, we use TFP as the representative for company productivity, so the treatment effect must contain productivity evolution that comes from, for example, resource allocation, technological advancement, skills training, and management process optimization. To further confirm our analysis, we also examined the Kernel distribution of TFP by export status and year. It was revealed that SME exporters have higher TFP than non-exporters; therefore, supporting our estimation results presented in Table 4.

One possible explanation for these above findings might be that an exporting firm bears a good chance for businesses to access broader markets and expand their production, resulting in better performance due to the economies of scale or higher revenue from a foreign market (Helpman and Krugman, 1985). Nonetheless, we prefer to focus on the role of their learning and adapting process. We learn that firms must encounter intensive rivalry when they export while meeting the demands for highly qualified goods of a new set of consumers (Bernard and Wagner, 1997). Exporters then strive to overcome this situation. They may do market research, invest in R&D, achieve more managerial experience, and afford more efficient production lines to enhance their core competency (Bernard and Jensen, 1999; Krugman *et al.*, 2011). Consequently, exporters form a shield that assures not only their survival but their expansion in the long term as well. Those results then advocate the learning-by-exporting hypothesis, in line with the findings of many previous empirical studies in Vietnam (Hiep and Ohta, 2009; Tra *et al.*, 2014; Long and Tam, 2018).

Interestingly, we find smaller TFP gaps between exporters and non-exporters in the five municipalities compared to the non-municipalities in Vietnam. It might be because the capacity

of exporting SMEs and non-exporting SMEs in the municipal areas is more homogeneous. The domestic market in the municipalities is also highly demanded, and the non-exporting SMEs in municipalities also face tough competition that only the best-performing SMEs could survive. Thus, locating in a municipality offers a larger domestic demand for an SME than in a non-municipality area. In 2020, the total payment to the government's budget from the five municipalities reached 774,000 billion VND, which accounted for 51.4% of the total national payment to the government budget. Export revenues in these municipalities attained 99.6 billion USD, equivalent to 35.4% of the national total export value. Apart from that, the urbanization and industrialization in the municipalities are also wider than in non-municipal provinces. In short, SMEs in municipal areas are more competitive and may gain better business conditions than their counterparts in non-municipal areas; hence, more support to boost exports may be given to SMEs in general and exporting SMEs in non-municipal areas.

6. Conclusion

This paper tested the learning-by-exporting hypothesis using microdata of Vietnamese SMEs from 2009 to 2014. Our empirical findings of the propensity score matching method show that exporters gain more productivity than non-exporters in Vietnam. Especially, the results also reveal strong evidence that the productivity differences between export and non-exporters are more significant in non-municipalities where there are smaller population size and density, a lower number of nonagricultural workers, and less developed infrastructure compared to the municipalities in the country.

For decades, the government in Vietnam has adopted a wide range of policies, intentionally aiding the development of the SME sector towards the global market. However, those choosing to serve a foreign market remain a minor fraction. In relation to our findings, we cast doubt on whether the Vietnamese government's attempts to facilitate SMEs well enough, especially for the exporters in non-centrally-controlled municipalities. Generally speaking, SMEs are flexible but quite fragile once facing issues such as lack of finance, poor technology, unskilled labor, or inefficient managerial processes. The problems are worsened in undeveloped areas of non-municipalities which are not urban center Grade 1 or Special urban central grade (Resolution 1211/2016/UBTVQH13). Therefore, more favorable policies supporting export should be considered to offer SMEs in non-municipalities.

This paper has several limitations. The explanations for some relevant issues such as why there remains just a small fraction of Vietnamese SMEs have their linkage with the global supply chains, whereas the majority serve only domestic markets (Hai, 2019), are not investigated in our study. Other limitations of the paper also need further research. Furthermore, this paper did not evaluate the roles of factors that may influence the export activities of the firms, such as the quality of export promotion channels, SMEs' connection with multinational enterprises, or firms that own foreign shares, the "red tapes" for SMEs registration and input import and output export, or innovation and technological progress.

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Appendix 1. Sample structure by firm size in each year from 2009 to 2014

Firm Size	Micro	Small	Medium	Total (100%)
2009	**1828** (72.77%)	**673** (26.79%)	**11** (0.44%)	**2512**
2010	**1823** (72.57%)	**676** (26.91%)	**13** (0.52%)	**2512**
2011	**1884** (74.11%)	**648** (25.49%)	**10** (0.39%)	**2542**
2012	**1912** (75.22%)	**622** (24.47%)	**8** (0.31%)	**2542**
2013	**2023** (76.43%)	**607** (22.93%)	**17** (0.64%)	**2647**
2014	**2021** (76.35%)	**607** (22.93%)	**19** (0.72%)	**2647**

Source: Authors' calculation