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*March*, 2024

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**Keywords: bypass road, Vietnam, National Highway No. 1A, transport infrastructure**

**JEL classification: O18, O53, P35, R41**

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# Economic Effects of Bypass Roads on National Highway No. 1 in Vietnam

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## Abstract

In Vietnam, a lot of bypass roads have been developed on the National Highway No. 1A (NH No. 1A) since 2000. The number of bypass roads developed after 2000 surpasses 90% of the existing bypass roads. The major types of the bypass roads were developed in the provincial capital to avoid traffic congestion. Other types, however, were developed as part of constructing bridges and tunnels. We adopted the technic of instrumental variable regression to estimate the economic effects of new bypass roads. In the first stage regression, we estimated the effects of constructing bridges and tunnels on the bypass development with variables that expressed geographical characteristics. In the second stage regression, we found positive effects of bypass roads on the gross provincial income and provincial monthly income per capita within the own province. Furthermore, the effects of the summed lengths of the bypass roads in other provinces surpass the former effects bypass road developed in its own province and we confirmed the greater mutual effects of bypass road on other provinces.

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## Introduction

The development of recent, modern, road infrastructure in Vietnam started with the First Highway Rehabilitation Project by the World Bank in 1993. According to the appraisal report, 'most of the roads are old; they were built before 1954 in the north and little construction occurred after 1970 in the south' (Socialist Republic of Vietnam 1993). From this description, we can imagine how poor the road conditions were at the beginning of the project. The Second Highway Rehabilitation Project began in 1996. In the implementation of the project, rehabilitation was conducted on four sections of the National Highway No. 1 (NH No. 1A): 1) Lang Son– Hanoi, 2) Vinh – Dong Ha, 3) Quang Ngai – Nha Trang, and 4) Can Tho – Nam Can from north to south (JICA 2010). Under the JICA-supported Vietnam National Transport Strategy Study (VITRANSS), in addition to the improvement of the primary and secondary inter-provincial transport network, there was also a focus on the integration of the tertiary network and rural and urban transport. To remove the bottlenecks of the primary and secondary roads, the development of urban bypass roads on the NH No. 1A was enumerated as one of the prioritized projects (JICA 2010). Not a few bypass-road were developed on the NH No. 1A since 2000. In fact, 57 bypass road sections were developed since 2000, while only six were developed before 2000, as defined in accordance with the method described later in the "data and methodologies" (Table 1). Currently, in and around most of the capitals of the municipalities and provinces on the NH No. 1A,[1] bypass roads have been developed.

(Table 1)

Vietnam is an elongated country from north to south with four central-government controlled-municipalities and 27 provinces located along the NH No. 1A.[2] Of the four municipalities, two megacities, Ha Noi and Ho Chi Minh City are in the north and the south respectively. Both megacities have large urban areas that are important commercial markets and production basements. There are also the municipality of Da Nang, and 15 provinces between Ha Noi and Ho Chi Minh City, four provinces above Ha Noi, and the municipality of Can Tho and seven provinces below Ho Chi Minh City.

With the bypass road projects, these provinces could be expected to grow with the increase in inter-provincial exchanges. Yet negative effects on the provinces could also be expected with the intensification of competition with other larger provinces and municipalities due to improvements in mutual access to markets, or "home-market effects" (Ihara *et. al.* 2015; Helpman and Krugman 1999).

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[1] The first-tier local administrative unit in Vietnam consists of municipalities and provinces, hereinafter collectively referred to as "provinces".

[2] From north to south, Lang Son, Bac Giang, Bac Ninh, Ha Noi City, Ha Nam, Ninh Binh, Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien-Hue, Da Nang City, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan, Binh Thuan, Dong Nai, Binh Duong, Ho Chi Minh City, Long An, Tien Giang, Vinh Long, Can Tho City, Hau Giang, Soc Trang, Bac Lieu, and Ca Mau.

If so, would the construction of new bypass roads cause positive effects on the province? If positive effects are confirmed, to what extent would production levels in each province be raised? Considering the characteristics of the NH No. 1A, that connects Ha Noi and Ho Chi Minh City, new bypass roads in other provinces could give the province better access to the two megacities. Which then are larger: the effects of new bypass roads within their own province, or the summed effects of new bypass roads in other provinces along the NH No. 1A? This paper answers these research questions.

From here, this paper has four sections. The first section introduces and reviews existing literature. The second section explains the data and methodologies adopted in this paper. The third section shows the estimated results, and the fourth section discusses them. The conclusion summarizes this paper and enumerates the challenges for the future.

## 1. Literature Review

Many articles have been published on the effects of road infrastructure development. For developing economies many studies are examined in Berg et al. (2017), a review article on the impacts of transport infrastructure. Many of the articles utilize difference-in-difference (DID) estimation or instrumental variable regression to clarify the issue of endogeneity in which dependent variables of economic growth can influence policy variables related to infrastructure development.

One example of the former is Dutta (2012) which shows the effects of India's Golden Quadrilateral project, a highway improvement program connecting the four cities of New Delhi, Mumbai, Kolkata, and Chennai, on the firms along the highways, and verifies the effects of decreasing the stock of input inventories for firms along the highways. Another example is Mu and Walle (2011) that analyzes the effects of the World Bank Development Project of rural road networks that are longer than 5,000 km in Vietnam.

Examples of instrumental variable regression are given in Faber (2014), Baum-Snow et al. (2018), and He et al. (2020). These articles are major works that deal with the development effects brought by the national trunk highway network system in China. The studies of the national highway network in China form a collection of studies of the development effects of a national highway system. Yet these articles show results different from the former two articles and the latest one, perhaps because of the time periods covered. Faber (2014) concludes that the network to connect provincial capitals and cities reduced GDP growth in peripheral counties while Baum-Snow et al. (2018)

shows that the peripheral regions also lose economic opportunities to develop manufacturing and service industries but “regional primates” gained an increase in economic effects and population. But He et al. (2020) argues that China’s expressway system helps poor rural counties grow faster in GDP compared with rich rural counties.

Few papers actually focus on the economic effects of Vietnam's national highway network system. Mu and Walle (2011), above, analyzes the effects of rural road networks while Mai and Carter (2023) discusses the Vietnamese government’s successful performances in developing expressways by adopting a state-owned enterprise from an institutional perspective. As part of Vietnam’s national highway network system, the NH No. 1 bypass road sections play an extremely important role, as does the North-South Expressway, in the early developing stage of the country’s long national territory from north to south. In analyzing the impact of a new bypass road on the development of five small and medium size towns in Israel, Ellas and Shiftan (2009) reviews articles on the impact of bypass roads and concludes that no clear answers were provided on the direction of the impact.

Without affluent research articles on bypass road development, this paper utilizes the instrumental variable regression to focus on the economic impacts of Vietnam’s NH No. 1 bypass roads.

## 2. Data and Methodology

A. Dependent variables

Before discussing the length of the bypass road section as the instrumental variable, we define a bypass road in accordance with following conditions:

i. a bypass name like “Phu Ly bypass” is commonly used
ii. an alternative road was constructed to avoid congestion in an area including the provincial capital
iii. even though a current section of the NH No. 1A has been considered a main section of the NH No. 1A, it had been developed as a bypass road
iv. a shortcut was achieved by constructing an alternative road with two or more lanes
v. the new and old bypass roads once separated and then meet again
vi. combinations of i) and v), ii) and v), iii) and v) or iv) and v) are sufficient conditions for a bypass road.

Regarding condition iii), above – ‘the North-South Railway was constructed in 1936 in the French Colonial Era and the NH No. 1A connects the North and the South in parallel with the railway' (Yamaguchi, 2016) – it should be kept in mind that the old bypass sections (OBSs) may be in parallel with the railway such that the newly-developed-bypass section (NDBS) separates from the NH No. 1A and then meets again. And the name of the section of the road can be changed.

With these conditions in mind, we selected 63 bypass sections, including some tiny ones (Table 1). Features of the bypass sections along the NH No. 1A, such as the length relationship between the NDBSs and the OBSs and the descriptive statistics of the NDBSs, are shown in Tables 2 and 3 respectively. The length relationship does not show significant difference. The longest bypass section of Table 3 is between Bac Giang City and Phap Van, Hoang Mai District in Ha Noi. The four-lane section between the junction with the NH No. 18 in Bac Ninh City and that with NH No. 5B was developed by the Asian Development Bank on 30 June 2002 (ADB 2003). The section between the junction with NH No. 5B and Phap Van was completed as a part of Ringway No. 3 of Greater Ha Noi with the completion of Thanh Tri Bridge, dated 3 February 2007 (Viet Jo 2007). The four-lane section was extended to Bac Giang City on 3 January 2016. But the expressways, including Bac Giang – Lang Son Expressway, are not regarded as bypass roads in this paper while the expressway is connected directly from the four-lane section between Bac Giang City and Phap Van.

(Table 2 and Table 3)

Table 4 shows the number of bypass sections by the ways to identify completion time. Of the 63 bypasses, we were able to confirm the completion *dates* of 37 bypass sections (58.7%), the completion *months* of eight bypass sections (12.7%) and the completion *years* of six bypass sections (9.5%). These completion times were identified with searching websites of newspapers and local government units.[3] If only the completion month of a bypass was confirmed, we assumed the completion date as 16$^{th}$ of the month or 15$^{th}$ of February. If only the year of a bypass was confirmed, we assumed the completion date to be July 2 of the year. For twelve bypasses (19.0%), even the completion year could not be confirmed: five of those (7.9%) had existed before 2000 as confirmed with the website of Google Time Lapse. The completion time based on "estimate by map" is the median value of the measurement years where the newer map

[3] The completion dates were identified when an article describes such news as 'an inauguration ceremony was held for a new bypass road' or 'operation of a bypass road was started,' or a tunnel or a bridge on the bypass section was completed because a bypass road could be completed when a bridge or a tunnel on the section was completed as a final stage in most of the cases.

shows the bypass section not shown by the older map. As for "guesstimates," two of them are estimated in cases where the OBS is supposed to be a section left behind when the road was widened to four lanes, maybe due to difficulties in acquiring the land. Another four "guesstimates" were identified by the year using Google Time Lapse when it shows the full section of a NDBS as a paved section. It is not easy to distinguish a paved section from an unpaved one.[4]

(Table 4)

We measured the lengths of OBSs and NDBSs as well as unseparated non-bypass sections (UNBSs) in a province by utilizing the websites of Open Route Service and Google Map and the date of completion. In this way, we produce the variable, the NDBS of *t* (year) and *j* (province). The value of the variable is set to be zero in a year when no bypass section had been developed. It is set to be the length of the bypass section of Province *j* after a new bypass section was developed, and it could be changed after the bypass section was extended and/or another bypass section was developed. Once the NDBS is set, the OBS of the old road will be found automatically, and the UNBS will be determined as the remaining unseparated non-bypass section. [5]

For second-stage dependent variables we use monthly income per capita (MICAP) and gross provincial income (GPI). The GPI was produced as follows. The method is to multiply MICAP of each province by each provincial population and by 12 months. Then, the data of GPI were realized with a GDP deflator with a fixed price of 2010. The MICAP for 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2019, 2020, 2021 and the population in each province are published by the General Statistics Office (GSO), the Ministry of Planning and Investment, Vietnam.

The point to be emphasized here is that the GPI for Hanoi City, Vinh Phuc and Hoa Binh Provinces before 2008 is estimated based on the provincial area after 2008 before the administrative boundaries of these provinces.[6] The arrangements at that time –

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[4] The unpaved road can be brighter than the paved one with sun-shining. And each year's aerial photo are the averaged ones.

[5] In addition to the length of NDBSs, we examined the value of NDBS/(UNBS+OBS), the ratio of the NDBS to the length for the entire section of the NH1A in the province, as another instrument variable, because the ratio can be more important in the case of a relatively smaller province. The value should be less than 1.0 or 100%. In some provinces like Thanh Hoa and Ha Tinh provinces, two bypass roads form a ring road. Since summing two NSBS against one OBS can surpass 100%, only the first-developed bypass road was selected for the calculation of the NDBS ratio. We estimated the instrument variable using logistics regression; the values were likely to diverge into 0.0 and 1.0 due to the incidental parameters problem (Heckman, 1979). We did not estimate the ratio of the NDBS.

[6] The entire old Ha Tai province except Tan Duc commune, Me Linh district of old Vinh Phuc province,

involving incorporation and disorganization not only at the district level but also at the commune level, and even the statistics of population census – do not publish the populations at commune level in Vietnam. To obtain values before 2008 close to reality, we utilize the annual data for Me Linh district that is a part of Ha Noi now and which used to be a part of Vinh Phuc province.[7] We only use unchanged population values of communes between 2006 and 2007,[8] although the effects of using such unchanged population are supposed to be negligible considering the sizes of the communes. Then we estimate the MICAP of Ha Noi, Vinh Phuc and Hoa Binh province as a weighted average value by population.

B. Situations of bypass roads on the NH No. 1A and explanatory variables

Looking at Vietnam from north to south again, we recognized that not a few bypass roads were developed in and/or around provincial capital cities. Such bypass roads were supposed to be developed to mitigate traffic congestion in/around provincial capital. In Vietnam, the district areas of provincial capitals of larger cities like Hanoi and Ho Chi Minh City are likely to be smaller and traffic congestion can easily occur, whereas those of under-developed provinces, for instance, in the Central Vietnam, are likely to be larger and such congestions are unlikely to occur. We use the ratio of the length of the section in the provincial capital district to that in the entire province to express the likelihood of traffic congestion. The expected sign is negative.

In addition to bypass roads to mitigate traffic congestions, we also recognize that not a few bypass roads have been developed to construct a new bridge to replace an antiquated bridge constructed during the French colonial era. For example, under a JICA project, the Bridge Rehabilitation Project II-3 on the NH No. 1A, 16 new bridges were constructed, of which 14 bridges were constructed with accompanying bypass road developments (Nakagi 2007). As an explanatory variable that indicates an impetus for bypass construction, we examined the number, sum, average length, and maximum length of bridges in a province along the old section of the NH No. 1A.[9] We confirmed that the fitting of the average length of river bridges was the best one. The length of a bridge was

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and Dong Xuan, Tien Xuan, Binh Yen and Binh Trung communes of old Hoa Binh province were merged into New Ha Noi. And Tan Duc commune of Ha Tai province was merged into new Vinh Phuc province.

[7] The population of Me Linh District is based on *Vinh Phuoc Statistical Year Book 2007*.

[8] The values and the sources of the population of the communes are: Tan Duc, 2,721, website of "Người Kể Sử (history teller)"; Dong Xuan, 4,495, website of "Việt Nam Mới"; Tien Xuan, 6,606, website of "Bản tin Bất Động Sản (selling real estate news)"; Binh Yen, 5,875, website of wikiwand; Binh Trung, 3,278, website of wikiwand.

[9] A variable which shows a bridge being antiquated was not examined due to its difficulty. The number of old bridges over rivers along the NH No.1A is 414. The number is based on the results we picked up from blue-colored lines from Google Map and Open Route Map.

measured as a length of bridge symbol of Open Route Service, shown in 100m increments. The expected sign of "average width of river bridges" is positive; in other words, the longer the average width, the higher the impetus for constructing a bypass road.

When a tunnel is constructed, the section that was previously a section of the NH No. 1A becomes an OBS, and the section with the tunnel becomes a NDBS. Thus, one NDBS takes place with constructing a tunnel. Old roads, such as the Hai Van Pass, are curvy and mountainous, characteristics of regions of past tunnel construction. As an indicator to show curviness, a degree of distortion in a province was examined, but it did not show a good performance. But as an indicator of being mountainous, the elevation of the highest point on the NH No. 1A in a province was examined and adopted due to its better performance. Table 5 shows the number of bypass sections by the type of the bypass. For alternative roads, various types of roads, such as the Ha Noi – Lang Son roads developed by Asian Development Bank, the NH No. 1C and the NH No. 1D fall into this category, but it was difficult to determine a specific explanatory variable for this category.

(Table 5)

Faber (2014), Baum-Snow et al. (2018) and He et al. (2020) focus on whether or not national trunk highway network connecting China's major cities enrich peripheries. Likewise, it is important to establish if new bypass road development on the NH No. 1A primarily benefits lower-income provinces, for instance, in the Central Vietnam. The shortest distance to the megacities shows income gaps among provinces; the value of the variable is the distance from the provincial capital city to Ha Noi from Lang Son to Quang Nam Province and that from the provincial capital city to Ho Chi Minh City from Quang Ngai to Ca Mau Province. In general, the further a province is from Ha Noi or Ho Chi Minh City, the lower its income level is likely to be, while the closer the province is to the two megacities, the higher its income level is likely to be. This variable also shows the balance of the central government policy's direction, that is, whether the government emphasizes the growth of suburban provinces around Ha Noi and Ho Chi Minh City or the reduction of the economic development gap with under-developed provinces. The expected sign is positive if the central government supports more bypass roads in provinces in the Central Vietnam and it is negative if the income level of these provinces does not rise in response to the development.

As a control variable, we employed a variable of market potential (MP) following Baum-Snow et. al. (2018). The market potential is not directly affected by the dependent variable, the GPI. With reference to Nguyen (2016), we produced the data of the sum of

GPI divided by direct distances between two provincial capitals:

$$MP_j = \Sigma^{n-1}{}_{l=1} (GPI_l / D_{j,l}), \text{ where} \qquad (2)$$

$MP_j$: market potential of province $j$
$GPI_l$ : GPI of province $l$ ($l \neq j$)
$D_{j,l}$ : distance between province $j$ and $l$

As another control variable, we adopt population density as of 2006. Table 6 shows the descriptive statistics of the variables employed in this paper.

(Table 6)

C. A methodology for the first stage equation
As stated in the literature review, we adopt the instrumental variable regression. The first stage equation is shown as in (2)

$$ln\ v_{j,t} = \beta^T{}_i\ ln\ X_{i,j,t} + \alpha_0 + \varepsilon_{j,t}, \text{ where} \qquad (2)$$

$v_{j,t}$ is the length of the NDBSs in province $j$ and in year $t$ as the instrumental variable
$X_{i,j,t}$ is a matrix of explanatory variables $i$, province $j$ and year $t$
$\beta_i$ is a coefficient vector of variable $i$
$\alpha_0$ is a constant term,
and $\varepsilon_{j,t}$ is an error term.

The matrix of variable $X_{i,j,t}$ is composed of the ratio of the length of the section in provincial capital district to that in entire province; the average value of river bridges; the elevation of the highest point; the shortest distance to two megacities; and the number of communes as in 2001. We try to estimate with the ordinary least square (OLS) and with the provincial random effect model. The estimated instrumental variable, $\hat{v}_{j,t}$ can be obtained with the following formula:

$$ln\ \hat{v}_{j,t} = \beta^T{}_i\ ln\ X_{i,j,t} + \alpha_0 \qquad (3)$$

D. A methodology for the second stage equation

The second stage equation is shown in (4):

$$ln\ y_{j,t} = \gamma\ ln\ \hat{v}_{j,t} + \delta_k{}^T\ ln\ Z_{k,\ j,\ t} + \alpha_1 + e_{j,t} \text{ where} \quad (4)$$

$y_{j,t}$ is gross provincial income (GPI) or monthly income per capita of *j* province and of year *t*

$\gamma$ is a coefficient of the instrumental variable, $\hat{v}_{j,t}$

$Z_{i,j,t}$ is a matrix of control variables *k*, province *j* and year *t*

$\alpha_1$ is a constant term

and $e_{j,t}$ is an error term.

We estimate the second stage equation of (4) with the OLS and the random effect model.

E. Another model for estimating additional effects of the NDBSs in other provinces

We add another variable, the sum of the lengths of the NDBSs developed in other provinces for the province *j*, $\hat{u}_{,j,t}$:

$$ln\ \hat{y}_{j,t} = \gamma\ ln\ \hat{v}_{j,t} + \lambda\ ln\ \hat{U}_{,j,t} + \delta_k{}^T\ ln\ Z_{k,,j,\ t} + \alpha_1 + e_{j,t} \text{ where} \quad (5)$$

$$\hat{u}_{,j,t} = \Sigma^{n-1}{}_{l=1}\ \hat{v}_{l,t} \quad (l \neq j) \quad (6)$$

**3. Estimated Results**

(1) First Stage Estimation

Table 7 shows the estimated results of the first stage regression, the natural logarithm of the length of the NDBSs (hereinafter, the expression of "natural logarithm of" may be omitted). The estimation model is the OLS for Case 1 and it is the provincial random effect model for Case 2. Regarding the explanatory variables, only the market potential is a variable that varies over time and changes by province. Other variables vary by province but do not change over time.

All the variables except the shortest distance from/to Ha Noi or Ho Chi Minh City (hereinafter, "the distance to a megacity") of Case (1) show statistical significance and express geographical characteristics of bypass roads in Vietnam as shown in Table 7.

(2) Economic effects of the NDBSs within each own province

Table 8 shows the estimated results of the second stage, the effects of the NDBSs within their own province on the GPI and monthly income per capita. Cases (3) – (6) are the estimated results for GPI and Cases (7) – (10) show those for the monthly income per capita. The estimated results of Cases (3), (5), (7) and (9) are based on the OLS and Cases (4), (6), (8) and (10) are based on the instrumental variable regression with provincial random effect. Cases (3), (4), (7) and (8) use provincial density as of 2006 and Cases (5), (6), (9) and (10) use "the distance to a megacity" as a control variable. These two control variables are not used at the same time because the further the distance to a megacity, the lower the population density is likely to be while the correlation coefficient of the logarithms of the two variables is –0.64.

The effects of the lengths for the NDBSs are positive with higher statistical significance. The signs of control variables of the market potential and population density in 2006 are expected ones while the coefficient of the population density in 2006 of Case (8) is not statistically significant. The coefficients of the distance to a megacity show different signs with statistical significance; the signs are negative for the GPI and positive for the monthly income per capita, respectively.

(3) Additional summed effects of the NDBSs in other provinces

Table 9 shows the estimated results of the summed effects of the NDBS in other provinces on the NH No. 1A (hereinafter, "summed effects") in addition to the effects of the NDBS within their own province ("within-effects"). Cases (11) – (14) are the estimated results for GPI and Cases (15) – (18) show those for monthly income per capita. The estimated results of Cases (11), (13), (15) and (17) are based on the OLS and those of Cases (12), (14), (16) and (18) are based on the instrumental variable regression with provincial random effect. Cases (11), (12), (15) and (18) use the market potential and the provincial density as of 2006 and Cases (13), (14), (17) and (18) use the distance to a megacity as a control variable. The latter cases do not employ the market potential because the variable is suspected to cause a multicollinearity problem and the variance inflation factor (VIF) of the logarithm of the market potential is 5.57. As for the correlation coefficients between the logarithm values of the within-effect and the summed effect, that of the original data for Cases (11), (13), (15) and (17) is 0.35 and that of the instrument variables for Cases (12), (14), (16) and (18) is –0.36. The correlation coefficients are not so significant while the signs of the former and the latter are different.

Compared with the within-effect, the coefficients of the summed effects are positive and had higher statistical significance while the within-effects are also positive with statistical significance of 5% and 10% in Cases (12), (13), (15) and (18). The coefficients of the market potential and the population density as of 2006 are positive and those of the distance to a megacity are negative, all with a statistical significance of 1% level.

**4. Discussion**

As for the estimated results of the first stage regression of Table 7, the signs of the coefficients draw out the geographical characteristics of the bypass roads. First, the negative statistically significant signs of the ratio of provincial capital section to the entire section on the NH No. 1A of each province show that new bypass roads were likely to be developed in/around relatively smaller provinces than the entire areas of provinces like Ha Noi and Ho Chi Minh City at an earlier stage. The statistically significant positive signs for the average width of river bridges and elevation of the highest point show that bypass roads were likely to be developed as the result of bridge and tunnel construction. And the much higher statistically significant positive sign of market potential reflects the characteristics of the NH No. 1A, which runs through the country from north to south. The positive coefficient of the distance to a megacity shows that bypass roads have also been developed in Central Vietnam. The NDBSs after constructing bridges were developed at an earlier stage in the 2000s in Central Vietnam. Not a few NDBSs have been developed in provinces like Quang Ngai and Binh Dinh province in Central Vietnam for the regional development.

The estimated results of Table 8 show that the within-effect, the lengths of new bypass road sections, bring positive effects to the GPI and the monthly income per capita for respective provinces. These results, however, do not confirm the home market effects of the new bypass road. The NDBS may result in an efficient transport system by reducing traffic congestions in respective regions and constructing new bridges and tunnels. The estimated coefficients of Case (4), (6), (8) and (10) of the within-effect suggest that the 1% increase in the new bypass road can raise the GPI by 33% and monthly income per capita by 12 – 18%.

The estimated results of Table 9 show that the summed effects, the effects of the NDBSs in other provinces, surpass the within effect, and the effects of the NDBSs within their own province. Nevertheless, some of the coefficients of the within effect are also positive with statistical significance. In accordance with the values of the coefficient of the summed effects, a 1 % increase in the new bypass road development of other provinces along the NH No. 1A raises the GPI by 49% – 62% and the monthly income per capita by 39% – 50%, and the within effects push up the GPI by 19% and the monthly income per capita by 4.5%. The effects of the NDBSs within their own province can become smaller together with the effects of the NDBSs in other provinces, compared with the within effect alone. The combined effects are more realistic than the within effect alone.

As for the effects on the areas far from Ha Noi or Ho Chi Minh City, including the provinces in Central Vietnam, the coefficients of the distance to a megacity are positive in Cases (9) and (10) of Table 8. But the coefficients are negative in six cases – (5), (6) of Table 8 and (13), (14), (17) and (18) of Table 9. All have a statistical significance of 1% level. It is suspected that the positive signs in Cases (9) and (10) are affected by the market potential, and the correlation with the distance to a megacity is –0.64. When estimating the GPI of Cases (9) and (10) without adopting the market potential, the coefficients of the distance to a megacity of Cases (9) and (10) have become –0.19502 and –0.18185 with a statistical significance of 1% level. We can conclude that the effects of the distance to a megacity on the GPI and monthly income per capita are negative, but the effects on the instrumental variable of the length of the NDBS in Table 5 are positive. Thus, it is supposed that new bypass roads have been positively developed in Central Vietnam but the effects on the GPI and monthly income per capita have been limited.

## Conclusion

In Vietnam, a lot of bypass roads have been developed on the NH No. 1A since 2000. More than 90% of existing bypass roads on the NH No. 1A were constructed after 2000 according to our survey. With searching bypass road sections on the NH No. 1A from north to south on a map of Vietnam, we confirmed that the number of such bypass road sections is 63. We also measured the lengths of these bypass road sections and confirmed – or estimated in some cases – their completion dates. We also produced data of gross provincial incomes. In this way, we produced a panel data file of GPI and a variable of bypass road sections. Finally, we tried to estimate the economic effects of constructing bypass road on the NH No. 1A.

In analyzing the economic effects of infrastructure development, we have to be careful with the issue of endogeneity. We chose to rule out endogeneity by using the instrumental variable regression. In the first stage regression, we could show the statistical significances of several geographical conditions of bypass roads. First, bypass roads tend to be constructed in a province with a relatively smaller provincial capital compared with the area of an entire province like Ha Noi and Ho Chi Minh City. Second, we captured the trends of some bypass roads being developed to build a new bridge to replace the antiquated bridge constructed during the French colonial era and to construct tunnels with a variable of elevation of the highest point.

According to the second stage of instrumental variable regression, the effects of developing bypass roads within a province alone on the gross provincial income and monthly income per capita are positive with statistical significance although the home market effects have not been confirmed. Considering the additional summed effects of new bypass roads developed in other provinces, they surpassed the effects of new bypass road developed within their own province. In short, developing new bypass roads give positive economic effects to their own province and other provinces; it is supposed to give all provinces better access to the two megacities, Ha Noi and Ho Chi Minh City, and eased the congestion in the city areas. It has been estimated that the 1% increase in the summed length of bypass roads in other provinces and in the length of bypass roads in its own province can push up the GPI by 49% – 62% and by 5.6%, respectively, and the monthly income per capita by 39% – 50% and by 0.5%, respectively. Regarding the economic effects on the provinces in Central Vietnam, the estimated results of the first stage showed that several bypass roads have been developed in the provinces of Central Vietnam while the economic effects on the GPI and monthly income per capita have been limited.

A review of future challenges would first consider the effects of the North-South Expressway under construction in various parts of Vietnam. It is also necessary to include not only the provinces along the NH No. 1A, but also other provinces in the country as areas to which economic effects will be brought. Finally, the negative effects of developing bypass roads, reported in the media, should include such matters as damage to roads too soon after construction, the financial burden on the provincial government, and frequent traffic accidents. Such challenges remind us that our study has only begun.

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**Table 1 The number of bypass sections by completion year**

| Completion year | Number | (%) |
|---|---|---|
| before 2000 | 6 | (9.5) |
| 2000-2004 | 12 | (19.0) |
| 2005-2009 | 7 | (11.1) |
| 2010-2014 | 18 | (28.6) |
| 2015-2019 | 19 | (30.2) |
| 2020- | 1 | (1.6) |
| Total | 63 | (100.0) |

Notes: 1) Some bypass sections have been extended. Yet the completion year in the table is based on when the bypass section was first developed.
2) For identifying the completion time, see Table 4 and subsection of "(1) Dependent variables in "2. Data and methodologies."
Source: The authors' survey results.

**Table 2 the length relationship between the newly-developed bypass section (NDBS) and the old bypass section (OBS)**

| the length relationship | Number | (%) |
|---|---|---|
| NBDS < OBS | 29 | (46.0) |
| NBDS > OBS | 32 | (50.8) |
| NBDS and OBS are equvalent | 2 | (3.2) |
| Total | 63 | (100.0) |

Note: the lengths are based on the current lengths (as of 2022) when we conducted a field survey from north to south.
Source: The authors' survey results.

**Table 3 Descriptive statistics of the newly-developed bypass sections (NDBSs)**

| Min | Max | Average | Median | S.D. |
|---|---|---|---|---|
| 0.4 | 63.4 | 13.1 | 8.1 | 12.1 |

Note: the lengths are based on the current lengths (as of 2022) when we conducted a field survey from north to south.

Source: The authors' survey results.

**Table 4 The number of bypass sections by the way to identify the completion time**

| Way how to identify completion time | Number | (%) |
|---|---|---|
| Date | 37 | (58.7) |
| Month | 8 | (12.7) |
| Year | 6 | (9.5) |
| before 2000 | 5 | (7.9) |
| Estimate by Map | 1 | (1.6) |
| Guesstimate | 6 | (9.5) |
| Total | 63 | (100.0) |

Source: The authors' survey results.

**Table 5 The number of newly-developed bypass sections (NDBSs) by type**

| Type of bypass road section | Number | (%) |
|---|---|---|
| in/around provincial capital | 22 | 35% |
| as a result of bridge construction | 12 | 19% |
| as an alternative road | 8 | 13% |
| as a result of tunnel construction | 7 | 11% |
| others | 14 | 22% |
| Total | 63 | 100% |

Note: Some bypass sections have multiple types. The categorization was conducted with prioritized order of bypass road in/around provincial capital, as a result of bridge and tunnel construction and alternative roads.

Source: The authors' survey results.

**Table 6 Descriptive statistics of the variables used in this paper**

| Variables | Unit | Min | Max | Average | Median | S.D. |
|---|---|---|---|---|---|---|
| Distance for new bypass Section | km | 0.405 | 68.105 | 16.760 | 9.405 | 18.009 |
| New bypass road ratio（NDBS/ [UNBS+OBS]) | % | 0.0 | 97.6 | 25.2 | 19.6 | 26.2 |
| Provincial capital ratio on old road | % | 0.0 | 60.3 | 16.7 | 12.9 | 13.3 |
| Old road distance from/to the nearer of Ha Noi and Ho Chi Minh City | km | 0.0 | 770.6 | 259.0 | 175.8 | 249.6 |
| Average Width of River Bridges in Province | m | 20 | 483 | 208 | 184 | 111 |
| Elevation of the Highest Points on Old Roads in Each Province | m | 5 | 478 | 97 | 35 | 133 |
| Real gross provincial income (2010 price) | thousand VNDs | 597,017 | 453,896,817 | 43,153,660 | 22,089,093 | 72,729,266 |
| Real monthly income (2010 price) | thousand VNDs | 632 | 4,603 | 1,811 | 1,729 | 825 |
| Real market potential | thousand VNDs | 2,338,814 | 39,002,767 | 9,894,880 | 7,363,957 | 7,050,962 |
| Population density in 2006 (persons/km$^2$) | 000/km$^2$ | 90 | 2,910 | 514 | 317 | 578 |

Note When we take a natural logarithm of the variable that includes zero, all the values of the variable obtain the smallest value of the variable except zero.
Source: produced by the authors in accordance with Open Route Map and Google Map and the statistics of General Statistics Office (GSO) of Vietnam.

**Table 7 Estimated results of First Stage Regression**

| Dependent variable | *ln* Distance of NDBS | |
|---|---|---|
| Case | (1) | (2) |
| *ln* Ratio of provincial capital section to the section of the entire province | -0.4253*** | -0.5439* |
| | (0.127) | (0.310) |
| *ln* average width of river bridges | 0.6198*** | 0.6875** |
| | (0.123) | (0.304) |
| *ln* elevation of the highest point | 0.6101*** | 0.6585*** |
| | (0.060) | (0.147) |
| *ln* Market Potential | 1.0561*** | 1.8028*** |
| | (0.170) | (0.121) |
| *ln* Shortest distance from/to Ha Noi or Ho Chi Minh City | 0.1234 | 0.345* |
| | (0.087) | (0.179) |
| Constant | -21.6684*** | -35.3766*** |
| | (3.194) | (2.783) |
| Number of observations | 310 | 310 |
| R-Square | 0.3425 | 0.3314 |
| OLS | Yes | No |
| Logistic Regression | No | No |
| Provincial RE | No | Yes |

Notes: 1) The values in the parentheses on the lower lines are standard errors.
2) *** significant at 1% level, ** at 5% level and * at 10% level.
3) R-Square for the OLS is the adjusted R-Square, while that for the provincial random effect regression is the overall R-Square.

Source: The authors' estimation.

**Table 8 Estimated results with effects of new bypass sections developed in their own province**

| Dependent Variable | *ln* GPI | | | |
|---|---|---|---|---|
| Case | (3) | (4) | (5) | (6) |
| *ln* Distances for new bypass road section | 0.1346***<br>(0.0340) | 0.3317***<br>(0.0980) | 0.1454***<br>(0.0350) | 0.3274***<br>(0.089) |
| *ln* Market potential | 0.6378***<br>(0.098) | 0.7192***<br>(0.179) | 0.5577***<br>(0.120) | 0.6688***<br>(0.168) |
| *ln* Population Density as of 2006 | 0.3917***<br>(0.079) | 0.3729**<br>(0.171) | | |
| *ln* Shortest distance from/to Ha Noi or Ho Chi Minh City | | | -0.2462***<br>(0.065) | -0.2242**<br>(0.104) |
| Constant | 4.1966***<br>(1.410) | 2.6375<br>(2.475) | 8.9733***<br>(2.129) | 6.7513**<br>(2.922) |
| Number of Observation | 310 | 310 | 310 | 310 |
| R-Square | 0.3072 | 0.2767 | 0.2854 | 0.2614 |
| OLS | Yes | No | Yes | No |
| Instrumental variable regression | No | Yes | No | Yes |
| Provincial RE | No | Yes | No | Yes |

| Dependent Variable | *ln* Monthly income per capita | | | |
|---|---|---|---|---|
| Case | (7) | (8) | (9) | (10) |
| *ln* Distances for new bypass road section | 0.0686***<br>(0.009) | 0.182***<br>(0.049) | 0.0639***<br>(0.009) | 0.118***<br>(0.018) |
| *ln* Market potential | 0.4573***<br>(0.027) | 0.5357***<br>(0.092) | 0.5672***<br>(0.032) | 0.6205***<br>(0.035) |
| *ln* Population Density as of 2006 | 0.0817***<br>(0.021) | 0.0617<br>(0.089) | | |
| *ln* Shortest distance from/to Ha Noi or Ho Chi Minh City | | | 0.0503***<br>(0.017) | 0.0641***<br>(0.021) |
| Constant | -0.4713*<br>(0.383) | -1.8163<br>(1.239) | -1.9855***<br>(0.574) | -3.0053***<br>(0.600) |
| Number of Observation | 310 | 310 | 310 | 310 |
| R-Square | 0.6323 | 0.5616 | 0.625 | 0.6062 |
| OLS | Yes | No | Yes | No |
| Instrumental variable regression | No | Yes | No | Yes |
| Provincial RE | No | Yes | No | Yes |

Notes: 1) The values in the parentheses on the lower lines are standard errors.
2) *** significant at 1% level, ** at 5% level and * at 10% level.
3) R-Square for the OLS is the adjusted R-Square, while that for the provincial random effect regression is the overall R-Square.

Source: The authors' estimation.

**Table 9 Estimated results with effects of new bypass developments in the own provinces and other overall provinces**

| Dependent Variable | *ln* GPI | | | |
|---|---|---|---|---|
| Case | (11) | (12) | (13) | (14) |
| *ln* Distances for new bypass road section | 0.0479 | 0.1889* | 0.056* | 0.1465 |
| | (0.036) | (0.113) | (0.034) | (0.109) |
| *ln* Sum of new bypass road sections in all other provinces | 1.2099*** | 0.4865*** | 1.3599*** | 0.6192*** |
| | (0.214) | (0.185) | (0.152) | (0.125) |
| *ln* Market potential | 0.1298 | 0.158 | | |
| | (0.130) | (0.254) | | |
| *ln* Population Density as of 2006 | 0.5635*** | 0.6106*** | | |
| | (0.081) | (0.171) | | |
| *ln* Shortest distance from/to Ha Noi or Ho Chi Minh City | | | -0.4370*** | -0.4479*** |
| | | | (0.044) | (0.093) |
| Constant | 3.9864*** | 7.595*** | 10.5993*** | 15.2300*** |
| | (1.344) | (2.851) | (0.945) | (0.771) |
| Number of Observation | 310 | 310 | 310 | 310 |
| R-Square | 0.371 | 0.385 | 0.394 | 0.389 |
| OLS | Yes | No | Yes | No |
| Instrumental variable regression | No | Yes | No | Yes |
| Provincial RE | No | Yes | No | Yes |

| Dependent Variable | *ln* Monthly income per capita | | | |
|---|---|---|---|---|
| Case | (15) | (16) | (17) | (18) |
| *ln* Distances for new bypass road section | 0.0196** | 0.0402 | 0.0126 | 0.0447* |
| | (0.008) | (0.026) | (0.008) | (0.026) |
| *ln* Sum of new bypass road sections in all other provinces | 0.6826*** | 0.3982*** | 0.8802*** | 0.4985*** |
| | (0.047) | (0.039) | (0.038) | (0.008) |
| *ln* Market potential | 0.1707*** | 0.178*** | | |
| | (0.028) | (0.069) | | |
| *ln* Population Density as of 2006 | 0.1787*** | 0.1729*** | | |
| | (0.018) | (0.048) | | |
| *ln* Shortest distance from/to Ha Noi or Ho Chi Minh City | | | -0.1482*** | -0.1454*** |
| | | | (0.011) | (0.033) |
| Constant | -0.5899 | 1.2323 | 2.7086*** | 5.2149*** |
| | (0.294) | (0.762) | (0.236) | (0.180) |
| Number of Observation | 310 | 310 | 310 | 310 |
| R-Square | 0.783 | 0.783 | 0.729 | 0.721 |
| OLS | Yes | No | Yes | No |
| Instrumental variable regression | No | Yes | No | Yes |
| Provincial RE | No | Yes | No | Yes |

Notes: 1) The values in the parentheses on the lower lines are standard errors.
2) *** significant at 1% level, ** at 5% level and * at 10% level.
3) R-Square for the OLS is the adjusted R-Square, while that for the provincial random effect regression is the overall R-Square.

Source: The authors' estimation.