# 科技部補助專題研究計畫成果報告
# 期末報告

## 檢測貿易流量與所得不均度間的非線性關係

計 畫 類 別 ： 個別型計畫
計 畫 編 號 ： MOST 104-2410-H-004-011-
執 行 期 間 ： 104年08月01日至105年10月31日
執 行 單 位 ： 國立政治大學國際經營與貿易學系

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中 華 民 國 106 年 01 月 31 日

中 文 摘 要 ： 貿易如何影響所得分配一直是貿易學者討論的課題。很多實證上的研究試圖找到兩者間的關係。然而該關係似乎隨時間及國家而有所不同。晚近的研究指出之所以會有此結果，可能是因為該關係並非線性所致。本文之目的在於提供一理論模型，解釋財務市場的摩擦如何產生該非線性關係，並進一步透過理論所得之結構式，檢測理論的正確性。

中 文 關 鍵 詞 ： 異質生產者、財務市場摩擦、所得分配不平均、國際貿易、內生需求彈性

英 文 摘 要 ： There is a tradition for trade economists to discuss the impact of trade volume on income distribution. A lot of empirical research tries to find a definite relationship between those two variables. However, economists grapple with the problem that evidence changes across countries and time. Recent research points out the possibility that it is caused by their nonlinear relationship. The purpose of this article is to provide a way to test this nonlinear relationship. We first propose a simple theoretical model to explain the relationship could be nonlinear because of frictions in the financial market. We then show that the structural equation can be derived from the model and how observable data can be used to test its validity.

英 文 關 鍵 詞 ： Heterogeneous Producers, Financial Market Frictions, Income Inequality, International Trade, Endogenous Demand Elasticity

# 1 Introduction

There is a tradition for trade economists to discuss the impact of trade volume on the income distribution.[1] Many empirical researchers try to find a definite relationship between those two variables. However, economists grapple with the problem that evidence changes across time and countries.[2] Recent research points out the possibility that it is caused by their nonlinear relationship.[3]

The purpose of this research is to provide a way to test this nonlinearity. We first propose a theoretical model to explain that the relationship could be nonlinear because of frictions in the financial market. We then show that the structural equation can be derived from the model and how observable data can be used to test its validity.

In the theoretical model, trade renders the opportunity for producers to access foreign demand while it also increases competition level (reflected on the increase in demand elasticity). The first impact increases the revenue of producers while the second one generates negative impact. Producers are asymmetrically affected by both effects. Frictions in the financial market are the source of asymmetry. The cost of production of the poor agents is higher because of the high borrowing rate caused by the friction. Their ability to obtain the benefit of accessing larger market is weaker but they suffer more from the reduction of revenue and profit caused by the increase in competition level. On the contrary, initially, for the wealthy agents the benefit of enlarging market outweighs the increase in elasticity because they are self-financing. Trade generates the redistribution of income and enlarges inequality. However, inequality does not always increase with degree of trade

[1] It is well known that the major motivation of the specific factor model and the Heckscher-Ohlin model is to characterize the plausible impact of trade on income distribution. In the Heckschoer-Ohlin model, according to the Stolper-Samuelson theorem, there is a one for one correspondence between commodity price and factor price. Since commodity price changes because of trade, factor price and hence income distribution changes as well.

[2] For instance, in 1995, Krugman (1995) argues that "[i]t is probably fair to say that a preponderance of research to date suggests that the impact of third world exports on first world labor markets has been small[,]" but in 2008, Krugman (2008) changes his attitude by saying that "it's no longer safe to assert that trade's impact on the income distribution in wealthy countries is fairly minor." Gourdon, Maystre, and de Melo (2006) and Chen (2007) find that trade increases inequality. Reuveny and Li (2003) finds that the opposite is true. Dollar and Kray (2002) and Perry and Olarreaga (2006) find that the openness variable is insignificant.

[3] See Dobson and Ramlogan (2009), Helpman, Itskhoki, and Redding (2010), Helpman, Itskhoki, Muendler, and Redding (2012) and Jalil (2012).

liberalization. As competition is getting higher, more firms earn normal profit. Furthermore, as more poor agents leave the market, survival firms are more homogeneous and the impact is more symmetric.

By assuming the initial distribution of capital endowment we have derive a workable theoretical model and its implied non-linear relationship between Ginin coefficient and trade volume. We are still input efforts to finish the empirical part.

The idea is related to the recent studies showing that degree of openness and the inequality might be nonlinear, the so-called "Openness Kutznet Curve". Inequality first increases with degree of openness and after it reaches the maximum, it decreases as trade is more liberalized. The idea is initially proposed by Dobson and Ramlogan (2009). Helpman, Itskhoki, and Redding (2010) argues that it might be caused by the search and matching frictions in the labor market. Helpman, Itskhoki, Muendler, and Redding (2012) tests the idea of Helpman, Itskhoki, and Redding (2010) by using Brazil data. We argue that the nonlinearity is caused by the frictions in the financial market and try to be the first one to confirm it empirically.

# 2 The Model

## 2.1 Setup of the Model

There are continuous number of countries with mass $C$. Each country is populated with continuous number of agents with mass $\overline{L}$. Each agent shares the same utility function,

$$V = \mu \ln u + q \quad 0 < \mu < 1,$$

where $q$ is the consumption of a homogenous good and $u$ is the subutility derived from consuming differentiated goods and $\mu$ is a parameter that indicates the degree of preference for differentiated goods. I follow Feenstra (2003) and Rodriguez-Lopez (2012) to assume that $u$ satisfies the symmetric translog expenditure function

$$\begin{aligned} \ln E = & \ln u_m + \frac{1}{2\gamma N} + \frac{1}{N}\int_{\omega\in\Omega} \ln p(\omega) d\omega \\ & + \frac{\gamma}{2N}\int\int_{\omega,\omega'\in\Omega} \ln p(\omega)\left[\ln p(\omega') - \ln p(\omega)\right] d\omega' d\omega, \end{aligned} \tag{1}$$

where $E$ is the total expenditure on differentiated goods, $\Omega$ is the set of available goods, $N$ is the measure of the set, $\omega$ is the index of differentiated

goods, $p(\omega)$ is the price of good $\omega$ and $\gamma > 0$ is related to the elasticity of demand.

Capital is the only input but not distributed evenly between consumers. There are two groups of consumers, the $l$ group and the $h$ group. $\Lambda_l$ percent of population is $l$ group and each of its member owns $K_l$ amount of capital. $\Lambda_h$ percent of population is $h$ group and each of its members owns $K_h$ amount of capital. $K_h > K_l$. In the sector producing differentiated goods, without loss of generality, we assume that one agent cannot manage more than one firm. To establish a firm, an agent has to invest $f$ amount of capital before any unit of production. Then they use one unit of capital to produce one unit of good. In the sector producing the homogeneous good, one unit of capital is used to produce one unit of $q$. $q$ is treated as a numeraire. The market of differentiated goods is monopolistically competitive while the market the homogeneous good is perfectly competitive.

Factor market is perfectly competitive; however there are frictions in the capital market. We follow Galor and Zeira (1993). Without monitor, the borrower can renege on a contract without punishment. Lenders can invest $z$ amount of capital to monitor and if so the borrowers have to pay $\beta z$ if they renege on the contract. $\beta > 0$ is an inverse measure of market friction.

## 2.2 Equilibrium

Because of the quasilinear utility function, if $q > 0$, the price of $q$ and the marginal utility of income is fixed as one. In this case, the total expenditure on differentiated goods in each country is $\mu L$. It implies the demand of capital derived from producing the differentiated goods cannot exceed $\mu L$.[4] Therefore, if the supply of capital is higher than $\mu L$, then $q > 0$ can be an equilibrium. We assume the supply of capital is large enough so that it is true.

Let $i$ be the interest rate and $d$ is the amount of lending. To pursue profit maximization, the following inequality must be satisfied:

$$di \leq \beta z,$$

otherwise the borrower renege on the contract. Since capital is costly, lenders must choose $z$ so that the equality is established; therefore $z = di/\beta$.

[4] If $q > 0$, the opportunity cost of capital is one. If the profit of producing differentiated good is greater or equal to zero, the cost of using capital cannot exceed $\mu L$. Therefore, the demand cannot exceed $\mu L$

Lenders also choose $d$ and $z$ so that the profit of lending is not negative:

$$d(i-1)-z=d\left[\frac{i\left(\beta-1\right)}{\beta}-1\right]\geq 0.$$

The above inequality implies $\beta>1$. We assume it is true otherwise there is no borrowing and lending market. Furthermore, because the outside option of capital investment is earning zero profit in producing $q$, the equality must be established and we have $i=\beta/(\beta-1)$. Apparently, the cost of production is lower if producers are self-financing.

Because $u$ is homothetic, the equilibrium of the market of the differentiated goods can be derived by using two-stage optimization. Consumers choose the consumption of differentiated goods to minimized the cost of obtaining one unit of $u$. Given the cost, consumers decide the total expenditure on differentiated goods. Because $q>0$, the second stage implies that the expenditure is $\mu$ and the world expenditure is $\mu CL$.

By using Shephard's Lemma, the expenditure share of good $\omega$ can be derived as

$$s(\omega)=\gamma\ln\left[\frac{\hat{p}}{p(\omega)}\right],$$

where $s$ denotes the expenditure share and

$$\hat{p}=exp\left(\frac{1}{\gamma N}+\frac{1}{N}\int_{\omega\in\Omega}\ln p(\omega)d\omega\right) \tag{2}$$

is the maximum price that a firm can charge. $\hat{p}$ increases when $N$ decreases or when the average of $\ln p(\omega)$ is higher; therefore $\hat{p}$ is an inverse measure of competition level. The elasticity can be derived by

$$\varepsilon_i(\varphi)=1-\frac{\partial\ln r_i(\varphi)}{\partial\ln p_i(\varphi)}=1+\frac{\gamma}{s_i(\varphi)}. \tag{3}$$

Let $q_1$ be the production level of the differentiated producer when the marginal cost is one and $q_2$ be the production level when the marginal cost is $i$. If $K<f+q_2$, the producers borrow and the production level is $q_2$. If $K>f+q_1$, the producers are self-financing and the production level is $q_1$. If $K\in(f+q_2,f+q_1)$, the production level is $K-f$. In this case, although the producers are self-financing, the production level is not optimized because they are capital constrained. Their production level is

$$p=\frac{\gamma\mu cL}{K-f}\mathcal{W}\left[\frac{\hat{p}\left(K-f\right)}{\gamma\mu cL}\right].$$

By using the above equation and the definition of Lambert $\mathcal{W}$ function,[5] the price is obtained as

$$p = \frac{\gamma\mu cL}{K-f}\mathcal{W}\left[\frac{\hat{p}\,(K-f)}{\gamma\mu cL}\right].$$

Let $m$ be the marginal cost of producer, then the optimal price of producers who borrow or self-financing but not capital constrained is

$$p = \mathcal{W}\left(\frac{\hat{p}}{m}e\right)m, \tag{4}$$

where $\mathcal{W}$ is the markup. Combining equation (3), we obtain

$$s = \gamma\left(\mathcal{W}-1\right).$$

To emphasize the importance of firm heterogeneity, we assume $f \in (K_h, K_f)$. Therefore, for the $l$ group, $m = i$. Because $q_1$ and $q_2$ are endogenous variables, as we will observe later, for different degree of trade liberalization, the marginal cost of the $h$ group can be 1 or $i$ or the producers can be capital constrained. If the $m = 1$, the profit is

$$\pi_1 = \mu CL\gamma\frac{\left(\mathcal{W}_1-1\right)^2}{\mathcal{W}_1} - f, \tag{5}$$

where the subscript 1 represents the variable corresponding to the case when $m = 1$. If $m = i$, the profit is

$$\pi_2 = \mu CL\gamma\frac{\left(\mathcal{W}_2-1\right)^2}{\mathcal{W}_2} + K(i-1) - fi, \tag{6}$$

where the subscript 2 represents the variable corresponding to the case when $m = i$. If the producers are capital constrained, the profit is

$$\gamma\mu cL\mathcal{W}_3 - K, \tag{7}$$

where the subscript 3 represents the case when the producers are capital constrained. Production is plausible only when the profit is nonnegative.

Finally, the market clearing condition is

$$\gamma cL\left[\left(\mathcal{W}_h-1\right)\lambda_h + \left(\mathcal{W}_l-1\right)\lambda_l\right] = 1, \tag{8}$$

[5]For an equation $\exp -cx = a(x-r)$, where $c$, $r$ and $a$ are constant, the solution of $x$ is

$$x = r + c^{-1}\mathcal{W}\left[\frac{c\exp(-cr)}{a}\right].$$

Please refer to Corless, Gonnet, Hare, Jeffrey, and Knuth (1996) for more details.

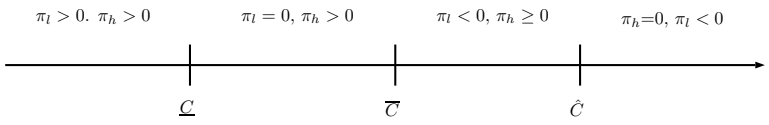


Figure 1: Trade Liberalization and Profit of Firms

where the subscript $l$ and $h$ represents the variables belonging to the $l$ and $h$ groups respectively and $\lambda$ is the mass of a group entering the market as a proportion of the total mass of the population in a country. According to the above analysis, $\mathcal{W}_l = \mathcal{W}_2$ but $W_h$ can be $\mathcal{W}_1$, $\mathcal{W}_2$ or $\mathcal{W}_3$ corresponding to different level of $C$.

# 3 Trade Liberalization and Inequality

In this section, we characterize how the profit of firms change with trade liberalization (increase in $C$). The result is summarized by Figure 1. We also derive the non-linear relationship between trade liberalization and inequality and obtain the structural regression model.

We first show that $\pi_l = 0$ and $\pi_h > 0$ if and only if $C \in \left[\underline{C}, \overline{C}\right]$. Apparently, if $\pi_l = 0$ it must be true that $\pi_h > 0$ and $\lambda_h^* = \Lambda_h$. If $C$ increases, according to equation (6), $\mathcal{W}_l^*$ decreases to maintain $\pi_l = 0$. $\hat{p}^*$ must decrease because $\mathcal{W}_l^*$ is an increasing function of it. $\mathcal{W}_h^*$ must decrease accordingly. Since the markup decreases, to maintain $\pi_l = 0$, the revenue of the $l$ group must increases. It implies that the revenue of the $h$ group must also increase. From equation (8), it can be observed that $\lambda_l^*$ must decrease. Therefore, when $C$ increase to a certain level, $\lambda_l^* = 0$ Let this level be $\overline{C}$. For $C > \overline{C}$, $\lambda_l^* < 0$ which is impossible, so that $\pi_l$ cannot be zero. For the same reason, when $C$ decreases, $\lambda_l^*$ increases. It reaches $\lambda_l^* = \Lambda_l$ when $C$ reaches a certain level. We name this level $\underline{C}$. For $C < \underline{C}$, $\lambda_l^* > \Lambda_l$ which is impossible; therefore $\pi_l$ cannot be zero.

We next proof that if $C < \underline{C}$, $\pi_l > 0$. We already know that if $\pi_l = 0$ $\lambda_l^* > \Lambda_l$; otherwise equation (8) cannot be satisfied. Since $\Lambda_l$ is the upper bound, it is impossible. If $\lambda_l$ decreases to $\Lambda_l$, $\mathcal{W}_l^*$ and $\mathcal{W}_h^*$ must increase. It can be observed that we can increase the pair of $\mathcal{W}_l^*$ and $\mathcal{W}_h^*$ to a level so that equation (8) is satisfied. Since $\mathcal{W}_l^*$ increases, $\pi_l$ must be greater than zero. Furthermore, in this range, when $C$ increases, $\mathcal{W}_l^*$ and $\mathcal{W}_h^*$ must decrease.

Finally, we proof that if $C \geq \overline{C}$ then $\pi_l < 0$; therefore $\lambda_l^* = 0$. Suppose it is not true. Consider the case when $\pi_l = 0$. In this case, $\lambda_h^* = \Lambda_h$. We have

known that if $C > \overline{C}$, to maintain $\pi_l = 0$ and satisfy equation (8), $\lambda_l^*$ must be negative. However, negative is not possible; therefore $\lambda_l^*$ should increase at least to zero. To maintain equation (8), $\mathcal{W}_l^*$ and $\mathcal{W}_h^*$ must decrease. It implies that $\pi_l$ must be negative and members of $l$ group do not enter. The above analysis also immediately rule out the possibility that $\pi_l > 0$.

Furthermore, when $C \geq \overline{C}$ we have

$$\mathcal{W}_h^* = (\gamma C L \lambda_h^*)^{-1} + 1$$

and if the firm is not capital constrained, the profit is

$$\pi_h = \frac{\mu}{\gamma \lambda_h^* \left(\gamma C L \lambda_h^* + 1\right)} - f;$$

if the firm borrows, the profit is

$$\pi_h = \frac{\mu}{\gamma \lambda_h^* \left(\gamma C L \lambda_h^* + 1\right)} + K(i-1) - fi;$$

otherwise

$$\pi_h = \gamma \mu C L \left[(\gamma C L \lambda_h^*)^{-1} + 1\right] - K_h.$$

We have known that when $C = \overline{C}$, $\pi_h > 0$; therefore $\lambda_h^* = \Lambda_h$. If $C$ further increases $\mathcal{W}_h^*$ must decrease. If the firm is not capital constrained, the profit decrease. If it is constrained, the profit increases. But in this case revenue increases as well. Therefore, when $C$ reaches certain level, the firm start borrowing and the profit decreases with $C$. When $C$ further increases to a certain level, name it $\hat{C}$, it must be true that $\pi_h = 0$. Then further increase in $C$ must correspond to the decrease in $\lambda_h^*$.

In this report, we use an example to show how the income inequality change with trade liberalization. We already known that for a given $C$, there is a distribution of markup and revenue between producers. The distribution of production level can then be derived. Suppose for a certain level of $C$, $h$ group also borrow so that $\mathcal{W}_h^* = \mathcal{W}_l^*$. Name this level of $C$ be $\tilde{C}$. Let $K_h$ is the one so that $\tilde{C} \in \left(\underline{C}, \overline{C}\right)$.

We have shown that the markup of firms decreases with $C$ and so does $\hat{p}$. It can be shown that

$$\frac{\partial \mathcal{W}}{\partial \hat{p}} \frac{\hat{p}}{\mathcal{W}} = \frac{1}{\mathcal{W} + 1}.$$

$\mathcal{W}$ is less sensitive to the change of $\hat{p}$ when $\mathcal{W}$ is higher. Since when $C < \tilde{C}$, $\mathcal{W}_h^* > \mathcal{W}_l^*$, the markup of $l$ group producers decrease faster when $C$ increases. $\pi_h - \pi_l$ increases with trade liberalization. When $\overline{C} \geq C \geq \tilde{C}$,

$\mathcal{W}_h^* = \mathcal{W}_l^*$. Since $\pi_l$ does not change in this range of $C$, $\pi_h - \pi_l$ does not change. We have shown that $\pi_h$ start decreasing with $C$ when $C > \overline{C}$.

In this report we use an example to show how we implement the empirical study. Let $z$ be the proportion of aggregate income belonging to the $l$ group. The Gini coefficient can be calculated as

$$G = \frac{z + \Lambda_l}{z + \Lambda_h}.$$

in the case when $\pi_l = 0$

$$z = \frac{K_l \Lambda_l}{(K_l \Lambda_l + \Lambda_h \pi_h)}.$$

If, for instance, the members of the $h$ group is fully self-financing, the profit of the members is described by equation (5). The profit of the members of the $l$ group is described by equation (6). Using equation (6), we can explicitly solve $\mathcal{W}_l^*$ as a function of, $f$, $\gamma$, $\beta$ and $\mu CL$ which is the volume of export.[6] Therefore, the markup can be solved as a explicit function of observable volume of export and unobservable but will be estimated parameters which are $f$ $\gamma$ and $\beta$. Since

$$\mathcal{W}_l^* = \mathcal{W}\left(\frac{\hat{p}^*}{i} e\right) \tag{9}$$

and Lambert $\mathcal{W}$ function is well defined and can be numerically calculated by Matlab, we can solve $\hat{p}^*$, given parameters and observable volume of trade for each iteration when we use non-linear least squares method. Since $\hat{p}^*$ is solved, $\pi_h$ can also be calculated by equation (5) in each iteration. If Gini coefficient is also observable and if we assume a structure of error term, the parameters of the system can be estimated. If the sign of parameters are the same as we assume in this model, we can confirm the non-linear relationship between volume of trade and inequality. The Gini coefficient is drawn from the United Nations World Income Inequality Database. Volume of trade is downloaded from the Center for International Data. We are still working on the empirical part.

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[6] $i = \beta/(\beta - 1)$ as we mentioned.

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# 科技部補助計畫衍生研發成果推廣資料表

日期:2017/01/29

| | |
|---|---|
| 科技部補助計畫 | 計畫名稱: 檢測貿易流量與所得不均度間的非線性關係 |
| | 計畫主持人: 徐則謙 |
| | 計畫編號: 104-2410-H-004-011- 學門領域: 國際經濟學 |

無研發成果推廣資料

# 104年度專題研究計畫成果彙整表

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|---|---|---|---|---|---|---|---|
| **計畫主持人：**徐則謙 | | | | | | **計畫編號：**104-2410-H-004-011- | |
| **計畫名稱：**檢測貿易流量與所得不均度間的非線性關係 | | | | | | | |
| 成果項目 | | | | | | 量化 | 單位 | 質化<br>（說明：各成果項目請附佐證資料或細項說明，如期刊名稱、年份、卷期、起訖頁數、證號...等） |
| 國內 | 學術性論文 | 期刊論文 | | | | 0 | 篇 | |
| | | 研討會論文 | | | | 0 | | |
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| | 智慧財產權及成果 | 專利權 | 發明專利 | 申請中 | | 0 | 件 | |
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| | | 博士後研究員 | 0 | | |
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| | | 博士後研究員 | 0 | | |
| | | 專任助理 | 0 | | |
| 其他成果<br>（無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。） | | | | | |

# 科技部補助專題研究計畫成果自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現（簡要敘述成果是否具有政策應用參考價值及具影響公共利益之重大發現）或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估
   □達成目標
   ■未達成目標（請說明，以100字為限）
      □實驗失敗
      □因故實驗中斷
      ■其他原因
   說明：
   計畫內容分為兩部分，一是建立理論模型並導出結構的迴歸模型，二是使用該迴歸模型檢測理論的正確性。完成前者耗費部分時間，所以後者並未在期限內完成。但若繼續進行應可達成目標。

2. 研究成果在學術期刊發表或申請專利等情形（請於其他欄註明專利及技轉之證號、合約、申請及洽談等詳細資訊）
   論文：□已發表 □未發表之文稿 ■撰寫中 □無
   專利：□已獲得 □申請中 ■無
   技轉：□已技轉 □洽談中 ■無
   其他：（以200字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性，以500字為限）
   晚近之實證發現貿易與所得分配的非線性關係，但與之相關之文獻大都專注於實證，少有堅實的理論基礎。就作者所知只有 Helpman et. al. (2012) 同時給合理論與實證。這些研究皆指出貿易雖會加深所得不均度，但只要持續開放，此不均度會開始下降，因此存在政策上的含意。本研究欲從借貸市場摩擦的角度切入，先建構適合導出實證回歸式的理論模型，從模型中得到隱含的結構回歸式，並檢測理論的正確性。如能完成應可有部分學術價值。

4. 主要發現
   本研究具有政策應用參考價值：■否 □是，建議提供機關
   （勾選「是」者，請列舉建議可提供施政參考之業務主管機關）
   本研究具影響公共利益之重大發現：■否 □是
   說明：（以150字為限）