行政院國家科學委員會專題研究計畫 成果報告

台灣養豬戶之成本與技術效率分析以及評估模式的建立
研究成果報告(精簡版)

計 畫 類 別 ：個別型
計 畫 編 號 ：NSC 98-2410-H-216-005-
執 行 期 間 ：98 年 08 月 01 日至 99 年 07 月 31 日
執 行 單 位 ：中華大學國際企業學系

計 畫 主 持 人：陳柏琪

計畫參與人員：碩士級-專任助理人員：賴志禮

處 理 方 式 ：本計畫可公開查詢

中 華 民 國 99 年 10 月 08 日

目錄

一、報告內容

本計劃以臺灣動物科技研究所「豬場經營線上管理系統」所蒐集之資料進行分析，分析內容分為兩部分。第一個部分中，係同時以隨機邊界法與資料包絡分析法，衡量 1995~2008 年連續記帳養豬戶之成本效率，同時剖析外在環境對效率的影響。第二個部分中則考量養豬戶通常同時進行不同生產階段的生產，而不同養豬戶之不同階段飼養效率不見得相同。因此，建立動態多部門資料包絡分析法以進一步描述個別養豬戶之不同生產階段的效率問題。以下分別說明之。

1. 成本效率的衡量

毛豬產業產值多年來在臺灣農產品生產中，其比重都是位居於前一、二名。根據 2008 年農業委員會的農業統計，毛豬產值為 686 億元，占農業總產值的 16.43 %，已超越水果業，躍居農業生產單項產值之冠，可見毛豬產業對臺灣農業的重要性。除此之外，毛豬的生產還帶動相關產業，包括飼養、飼料、動物藥品、獸醫、屠宰、肉品加工等，因此毛豬產業除繁榮農村經濟外，對社會亦具有安定的作用。

然而毛豬產業的發展也因為口蹄疫事件、臺灣加入世界貿易組織(World Trade Organization，以下簡稱 WTO)等因素的影響而倍受考驗。自 1997 年 3 月遭遇口蹄疫的重創以來，台灣生鮮豬肉痛失海外市場，嚴重壓縮養豬戶的生存空間；2002 年起又面臨台灣加入 WTO，開放豬肉進口加速市場競爭，對業者來說，無異是雪上加霜；2006 年國際穀物價格高漲，國內飼料大多來自進口，因此養豬戶的生產成本也隨著巨幅上揚，養豬業再次面臨嚴峻的考驗。

在上述事件中，尤以口蹄疫對毛豬產業的衝擊最為嚴重。許多養豬戶因全場豬隻被消毀而一夕之間傾家蕩產，而倖存者則面臨生鮮豬肉至今仍無法出口，銷售利潤大幅縮減的窘境，加上市場競爭、成本提高，因此，口蹄疫後陸續有豬場離牧退出經營，可見其影響

之深遠。然而，綜觀國內有關養豬戶的文獻，包括黃玉鴻、阮喜文與李淵百(1998)、張谷銘(2001)、黃玉鴻(2002)、呂秀英(2003)、楊志慶(2006)與陳柏琪等(2009)都未曾針對口蹄疫或加入 WTO 對於養豬戶生產行為的影響加以探討。因此，本文利用 1995~2008 年間參與臺灣動物科技研究所「豬場經營線上管理系統」之豬場的記帳資料，來觀察養豬戶成本效率之跨年變化，希望藉由跨年比較找出影響養豬戶經營績效的主要原因與未來改進之道。值得一提的是，透過這套系統所建立的記帳資料是目前國內保存時間最長、最完整的養豬成本與經營紀錄資料，相信藉由這項系統中資料的使用，當能提供寶貴訊息供政府輔導單位與養豬業者參考。

至於研究方法部分，資料包絡分析法 (Data Envelopment Analysis，以下簡稱 DEA)與隨機邊界分析法(Stochastic Frontier analysis，以下簡稱 SFA)是目前最常被用來探討生產效率的兩種分析方法，兩者各有其優缺點。DEA 屬於非參數確定邊界分析法，因此具有不需對無效率項的分配型態、成本函數的函數型態加以設定，可以免除因而引起的衡量誤差等問題的優點，但是會有將所有隨機誤差項均視為技術無效率因素而一併衡量的缺點；相反地，SFA 因屬於參數估計法，可以將誤差項與技術無效率因素分開觀察，因此具有可排除誤差項對效率值的干擾的優點。為了取兩者之長，增加本文分析之可信度，因此，本文將同時採用 SFA 與 DEA 方法來進行成本效率的衡量。

實證結果顯示，SFA 與 DEA 同期邊界的結果較為接近，兩者於 1995-2008 年之成本效率值平均分別為 0.875 與 0.842，顯示養豬戶一般仍有 12.5%~15.8%的成本節省空間，應該藉由跟模範豬場學習更有效率的投入使用方式並調整不同投入之配置來加以改善。而由 DEA 跨期邊界的結果可發現外在環境的變動，例如口蹄疫事件與加入 WTO 開放進口等，對毛豬產業成本效率的影響基本上都是相當立即且明顯，其中又以口蹄疫的影響最為顯著。此說明降低外在因素，由其是傳染性疾病防治，對養豬戶產銷影響之重要性。

經營變數的迴歸結果則顯示，同時經營種豬與肉豬銷售的多角化豬場與使用外購飼料

對於效率的提升皆有正向影響，而擴大生產規模也有助於豬場降低生產成本。但是豬場經營者本身的較高教育程度與較多經驗年數並未對豬場表現產生正面的幫助，所以經營者是否有扎實的專業訓練，並隨時吸收新資訊與學習新技術，靈活應變市場變化做出調整，反而應該是影響的關鍵。

參考文獻

呂秀英 (2003),「因應加入世界貿易組織(WTO)提昇臺灣養豬戶經營效率之研究」,《農業金融論叢》，49，49-81。

張谷銘 (2001),《臺灣連續記帳毛豬農場生產力變動之研究-Malmquist 指數法之應用》，中興大學農業經濟研究所碩士論文。

陳柏琪、黃玉鴻、許聖民與張靜貞 (2009)，「台灣養豬戶之效率分析：以連續記帳戶樣本為例」，《農業經濟叢刊》，15(1)，43-80。

黃玉鴻、阮喜文與李淵百 (1998),「一貫化豬場經營效益之評估－詹家牧場個案分析」,《農林學報》，47(2)，57-70。

黃玉鴻 (2002),《臺灣一貫化豬場經營管理資訊系統之建立》，中興大學畜產研究所博士論文。

楊志慶 (2006),《臺灣養豬示範戶生產效率及環境績效衡量之研究》，中興大學應用經濟研究所博士論文。

Aigner, D. J., C. A. K. Lovell, and P. Schmidt (1977), “Formulation and Estimation of Stochastic Frontier Production Function Models,” *Journal of Econometrics*, 6, 21-37.

Battese, G. E. and T. J. Coelli (1995), “A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data,” *Empirical Economics*, 20, 325-332.

Charnes, A., W. W. Cooper, and E. Rhodes (1978), “Measuring the Efficiency of Decision Making Units,” *European Journal of Operational Research*, 2. 429-444.

Coelli, T. J., D. S. P. Rao, C. J. O'Donnell, and G. E. Battese (2005), *An Introduction to Efficiency and Productivity Analysis*, 2^{nd} ed. New York : Springer Science+Business Media, Inc.

Farrell, M.J. (1957), “The Measurement of Productive Efficiency,” *Journal of the Royal Statistical Society*, Series A, 120, 253-290.

Galanopoulos, K., S. Aggelopoulos, I. Kamenidou, and K. Mattas (2006), “Assessing the Effects of Managerial and Production Practices on the Efficiency of Commercial Pig Farming,” *Agricultural Systems*, 88, 125-141.

Greene, W. H. (1990), "A Gamma-distributed Stochastic Frontier Model," *Journal of Econometrics*, 46, 41-164.

Iglesias, G., P. Castellanos, and A. Seijas (2010), "Measurement of Productive Efficiency with Frontier Methods: A Case Study for Wind Farms," *Energy Economics*, doi:10.1016/j.eneco.2010.03.004.

Kodde, D. A. and F. C. Palm (1986), "Wald Criteria for Jointly Testing Equality and Inequality Restrictions," *Econometrica*, 54 (5), 1243-1248.

Sharma, K. R., P. Leung, and H. M. Zaleski (1997), "Productive Efficiency of the Swine Industry in Hawaii: Stochastic Frontier vs. Data Envelopment Analysis," *Journal of Productivity Analysis*, 8, 447-459.

Sharma, K. R., P. Leung, and H. M. Zaleski (1999), "Technical, Allocative and Economic Efficiencies in Swine Production in Hawaii: A Comparison of Parametric and Nonparametric Approaches," *Agricultural Economics*, 20, 23-35.

Stevenson, R. E. (1980), "Likelihood Functions for Generalised Stochastic Frontier Estimation," *Journal of Econometrics*, 13, 57-66.

Tulkens, H., and P. Vanden Eeckaut (1995), "Non-parametric Efficiency, Progress and Regress Measures for Panel Data: Methodological Aspects," *European Journal of Operational Research*, 80, 474-499.

2. DEA 多部門網絡模型

Pork is one of the main animal protein sour ces around the world. Therefore, pig husbandry is an important livestock industry in many counties. However, farmers have been facing increasingly competitive and rigorous operating challenges in the last decade because of increased competition and feed prices. Following the general tendency of worldwide agricultural trade liberalization due to ongoing WTO negotiations (Galanopoulos et al. 2006), competition in the pig farming sector of many countries unavoidably increased. The prices of feed ingredients, e.g., corn and soybeans, have kept increasing and becoming more volatile since 2005.[1] For example, global prices of many crops nearly doubled between 2005 and 2007, and continued rising in early 2008 (OECD 2008). Further, the

[1] The report of OECD-FAO Agricultural Outlook 2009-2018 indicated that episodes of extreme price volatility similar to the hike in 2008 cannot be ruled out in coming years, particularly as commodity prices have become increasingly linked to oil and energy costs, and as environmental experts warn of more erratic weather conditions.

prices of corn and soybeans for the next decade after adjustment for inflation are projected to be 10-20% higher than the average prices for 1997-2006 (OECD-FAO 2009), suggesting that the pressure from high feed cost will not be alleviated. Because of the volatility of feed prices, farmers have difficulties in controlling feed cost and planning the future. With these challenges, farmers need to enhance their operating efficiency for survival and profitability. Measuring and monitoring production efficiency of pig farms are thus critical for farming managers and legislatures to make appropriate adjustments for production enhancement.

As for the efficiency measurement methods, due to the advantage of not needing to impose any explicit functional form on the data, and being able to easily accommodate multiple input and outputs cases, Data Envelopment Analysis (DEA) is one of the most popular approaches used to appraise firms' performance in the literature. Traditional DEA models usually deal with efficiency of input resources vs. output products of associated decision making units (DMUs) within cross-sectional data (Tone and Tsutsui, 2009a). However, Färe and Grosskopf (2000) had indicated that based on the traditional measurement, production is thought of as a "black box", and the actual transformation process of inputs into outputs is generally not modeled explicitly. Consequently, individual DMU managers would have difficulty retrieving specific information about the sources of inefficiency within their DMUs. Therefore, many variants on DEA have been developed to add more structure to the model to improve its real-world application.

Castelli et al. (2008) classified the DEA models which consider the internal structure of evaluated Decision making Units (DMUs) into three categories: shared flow, multilevel, and network models. Shared flow models, which were first developed by Beasley (1995) and subsequently revised by Mar Molinero (1996), Cook et al. (2000), and Tsai and Mar Molinero (2002), are often referred to as multi-activity or multi-component models. These models are applied when it is possible to partition a DMU as a collection of components that contend their inputs and/or outputs to other components of the same DMU. Multilevel models are referred to when some of the inputs (or outputs) of a DMU are also inputs (or outputs) of its subunits (or sub-DMUs), but some other inputs (or outputs) are not. The representative paper is the work of Cook et al. (1998). Network models, including static and dynamic frameworks, were first introduced by Färe and Grosskopf (1996). These models take intermediate flows among the subunits into account.

These abovementioned models have been commonly applied to assess the efficiencies of firms in various industries.[2] However, only a few studies such as Färe and Whittaker (1995) and Färe and Whittaker (1996), have employed these models for the livestock industry. Färe and Whittaker (1995) proposed a static network model that includes the intermediate flows into their dairy production problem. Färe and Whittaker (1996) further revised the model with a dynamic structure to analyze the efficiency of cattle producers with permits for grazing on public land. The sub-technologies considered in these two articles are crop and livestock production, and crop production became the input of the livestock production. Nevertheless, the several sub-processes within livestock production were not considered, such as breeding and farrowing sows and raising pigs to maturation. The efficiency of each sub-process contributes to the overall performance of a pig farm which performs all phases of production. Without considering all production phases of a livestock farmer, the conventional DEA model relinquishes underlying diagnostic values potentially available to management (Tone and Tsutsui, 2009b).

The major objective of this study is to propose a dynamic multi-activity network DEA (DMNDEA) structure to evaluate performance of Taiwanese farrow-to-finish pig farms, based on 2006 data. This model, combining the shared flow model and network model with the consideration of the non-zero slack, is expected to provide more comprehensive information about production efficiency to farmers than the traditional one. Particularly, traditional DEA, in which efficiency is measured radically, is often criticized for its assumption that inputs and outputs undergo proportional changes (Tone and Tsutsui 2009b) and for not considering the inefficiency associated with non-zero slack (Cooper et al. 2007; Fukuyama and Weber 2009). The idea of the directional slacks-based inefficiency (SBI) measure developed by (Fukuyama and Weber 2009) is incorporated into our model to allow inputs and outputs with non-proportional changes.

In order to better describe the technologies which make up hog production, in this study we divide the entire production operation of the farrow-to-finish system into two processes. One is the breed-to-farrow phase, whose activities include breeding females and their maintenance during pregnancy and nursing. The other one is the wean-to-finish phase, whose activities include care of pigs after weaning, and feeding them to a slaughter weight. Intuitively, the relationship between these two phases is consecutive, from breed-to-farrow to wean-to-finish. However, according to the operation characteristics of Taiwanese farrow-to-finish pig farms, their relationship as shown in Fig 2 is not only intertemporal and but also contemporaneous, because these two phase overlap or are operated simultaneously, even for the farms which adopt an all-in all-out system.

[2] Please refer to Castelli et al. (2008) for the relating literature reference.

Consequently, we indicate that the weaned pigs produced in the previous period (t-1 period) are treated as intermediate inputs and used to produce the finished hogs along with the inputs of feed, labor, capital and other variable inputs in the current period (t period). Further, the same four inputs shared to raise sows to produce weaned pigs become the input for the next period (t+1 period). The length for each period is designated as 6 months, since weaned piglets require 6 months to reach market weight in Taiwan.

Empirical results provide the following findings. First, although the overall technical inefficiencies obtained from DMNDEA do not appear to differ from those of a traditional one-stage model, the DMNDEA results show that the source for inefficiency in each farm differs. Some farms have inefficiency in the breed-to-farrow production phase and some in the wean-to-finish phase. This valuable information is unavailable from traditional models. Second, consideration of non-zero slack has a significant impact on the efficiency results, indicating the importance of counting all the slacks that exist in the model when performance evaluation using a DEA model is conducted. Third, the regression results show that the efficiency determinants in each production phase are not completely the same, indicating the need to identify the influential factors for each production phase. The policy implication is that if the inefficiency is attributed mainly to factors in the breed-to-farrow phase, efforts to concentrate on hog production business and expand operating scale as well as use more self-prepared feed would be helpful to improve performance. In contrast, if causes of the inefficiency are located in the wean-to-finish phase, adopting more automated equipment together with the above three strategies will be more effective in improving efficiency.

References

Asmild M, Hougaard JL (2006) Economic versus environmental improvement potentials of Danish pig farms. Agric Econ 35: 171–181

Beasley JE (1995) Determining teaching and research efficiencies. J Oper Res Soc 40(4):441-452

Castelli L, Pesenti R, Ukovich W (2008) A classification of DEA models when the internal structure of the decision making units is considered. Ann Oper Res. 10.1007/s10479-008-0414-2

Chung YH, Färe R, Grosskopf S (1997) Productivity and undesirable outputs: A directional distance function approach. J Environ Manag 51:229-240

Cook W, Chai D, Doyle J, Green R (1998) Hierarchies and groups in DEA. J Product Anal 10(2):177–198

Cook WD, Hababou M, Tuenter HJH (2000) Multicomponent efficiency measurement and shared inputs in Data

Envelopment Analysis: An application to sales and service performance in bank branches. J Product Anal 14: 209-224

Cooper WW, Huang Z, Li SX, Parker, BR, Pastor JT (2007) Efficiency aggregation with enhanced Russell measures in Data Envelopment analysis. Socio-Econ Plan Sci 41:1-21

Färe R, Grosskopf S (1996) Intertemporal production frontiers: With dynamic DEA. Kluwer Academic, in collaboration with R. Brännlund et al. Boston; London and Dordrecht

Färe R, Grosskopf S (2000) Network DEA. Socio-Econ Plan Sci 34:35-49

Färe R, Whittaker G (1995) An intermediate input model of dairy production using complex survey data. J Agric Econ 46(2):201-213

Färe R, Whittaker G (1996) Dynamic measurement of efficiency: An application to western public grazing. Intertemporal production frontiers: With dynamic DEA, R Fare and S Grosskopf, eds., Kluwer Academic, Boston; London and Dordrecht, 168-186

Fukuyama H, Weber WL (2009) A directional slacks-based measure of technical inefficiency. Socio-Econ Plan Sci. doi: 10.1016/j.seps.2008.12.001

Galanopoulos K, Aggelopoulos S, Kamenidou I, Mattas K (2006) Assessing the effects of managerial and production practices on the efficiency of commercial pig farming. Agric Syst 88: 125-141

Luenberger DG. (1992) Benefit function and duality. J Math Econ 21:461-481

Mar Molinero C, (1996) On the joint determination of efficiencies in a Data Envelopment Analysis Context. J Oper Res Soc 47:1279-1279.

Mugera AW, Featherstone AM (2008) Backyard hog production efficiency: Evidence from the Philippines. Asian Econ J 22 (3):267–287.

OECD (2008) Rising Food Prices: Causes and Consequences http://www.oecd.org/dataoecd/54/42/40847088.pdf

OECD-FAO (2009) Agricultural Outlook 2009-2018, http://www.agri-outlook.org/pages/0,2987,en_36774715_36775671_1_1_1_1_1,00.html

Oude Lansink A, Reinhard S (2004) Investigating technical efficiency and potential technological change in Dutch pig farming. Agric Syst 79:353-367

Piot-Lepetit I, Moing ML (2007) Productivity and environmental regulation: the effect of the nitrates directive in the French pig sector. Environ and Resource Econ 38:433–446

Rowland WW, Langemeier MR, Schurle BW, Featherstone AM (1998) A nonparametric efficiency analysis for a sample of Kansas efficiency analysis swine operations. J Agric and Appl Econ 30(l):189–199

Russell RR (1987) On the axiomatic approach to the measurement of technical efficiency. In Eichhorn W., ed., Measurement in Economics: Theory and Application of Economic Indices, Physica-Verlag, Heidelberg, 207-217

Sharma KR, Leung P, Zaleski HM (1997) Productive efficiency of the swine industry in Hawaii: Stochastic frontier vs. Data Envelopment Analysis. J Product Anal 8:447–459

Sharma KR, Leung P, Zaleski HM (1999) Technical, allocative and economic efficiencies in swine production in Hawaii: a comparison of parametric and nonparametric approaches. Agric Econ 20:23–35

Tsai PF, Mar Molinero C (2002) A variable returns to scale Data Envelopment Analysis model for the joint determination of efficiencies with an example of the UK health service. Eur J Oper Res 141:21-38

Tone K, Tsutsui M (2009a) Dynamic DEA: A slacks-based measure approach. Omega. doi: 10.1016/j.omega.2009.07.003

Tone K, Tsutsui M (2009b) Network DEA: A slacks-based measure approach. Eur J Oper Res 197: 243–252

Tonsor GT, Featherstone AM (2006) Heterogeneous production efficiency of specialized swine producers, paper prepared for presentation at the Southern Agricultural Economics Association Annual Meetings Orlando, Florida

二、計畫成果自評

本計畫研究內容適合於投稿至學術期刊，目前其中有關 DEA 多部門網絡模型部分之研究成果已於投稿至 Journal of Productivity Analysis (SCI, SSCI)，並根據 reviewers 的意見修改中。

無研發成果推廣資料

98 年度專題研究計畫研究成果彙整表

計畫主持人：陳柏琪	計畫編號：98-2410-H-216-005-
計畫名稱：台灣養豬戶之成本與技術效率分析以及評估模式的建立	

成果項目			量化：實際已達成數（被接受或已發表）	量化：預期總達成數(含實際已達成數)	量化：本計畫實際貢獻百分比	單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
國內	論文著作	期刊論文	0	2	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	1	0	100%		
國外	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (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。)	無

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

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：

2. 研究成果在學術期刊發表或申請專利等情形：

   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 100 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）

   本計畫研究內容適合於投稿至學術期刊，目前已於投稿至 Journal of Productivity Analysis (SCI, SSCI)，並根據 reviewers 的意見修改中。

   另一方面，根據本研究所建立的研究模型，可以提供其他也有興趣以動態 DEA 模型作為研究方法之研究參考。實證結果結果部分，則可提供業者與政府調整經營方向與制定政策參考。