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Economies of scale and scope in Macau's banking sector

Abstract

This paper uses a parametric approach within a translog cost function framework to estimate the economies of scale and scope in Macau's banking sector from 1995 to 2006. The results indicate significant diseconomies of scale and economies of scope for Macau banks throughout the sample period regardless of their size and ownership. Further analysis provides evidence of significant product-specific economies of scale and scope, which vary according to bank size and ownership. The findings suggest that Macau banks should diversify their asset portfolios to gain greater cost advantage. However, expansion in size should be discouraged under current technology because it appears to be cost ineffective. In addition, our findings lend strong support to the implementation of the universal banking model in Macau.

Keywords: Macau banking sector, economies of scale and scope, parametric methodology.
JEL Classification: G21.

Introduction

Banks are currently experiencing substantial competitive pressure domestically and internationally as a result of the global trend towards liberalizing financial services and increasing use of advanced technologies. In response to these competitive pressures, banks have attempted to adopt alternative strategies to reduce their production costs by exploiting economies of scale and scope.

In theory, the presence of economies of scale means that large banks have a cost advantage over small banks, while evidence of economies of scope implies that multi-product banks are more efficient than financial boutiques. A large amount of research has estimated the production economies of the banking sector over the past decade. However, as most of these studies are devoted to the banking sectors of developed economies, little attention has been paid to banks in the emerging markets[1].

China is one of the largest emerging economies. It has two Special Administrative Regions (SARs) which had been colonized by Portugal and the United Kingdom, respectively, for over a century. However, there are substantial differences between the banking sectors of these two regions. First, Hong Kong is an international financial center with around 150 licensed banks and a well-developed financial market. In contrast, Macau is an open but small economy with only 24 banks with full licenses and no stock market. Second, banks in Hong Kong are larger than banks in Macau in terms of asset size. The average asset size of the Hong Kong banks is around 24 times of the average asset size of the Macau banks. Third, in comparison to Macau banks, Hong Kong banks have developed more complicated products to both satisfy the needs of their general customers and improve their risk management mechanisms. Macau banks typically offer traditional banking products to their customers (e.g., current and savings accounts, loans, and bank cards). A few of them provide very limited investment services, such as foreign exchange trading and share brokerage services. In contrast, Hong Kong banks frequently offer securities, unit trusts, bonds, and various forms of structured products to satisfy customer investment needs.

Over the past decade, Macau benefited from the strong economic growth of Mainland China and the progress of economic integration with neighboring regions. Such a favorable business environment boosted demand for more complicated banking services, particularly in retail credit, project finance, wealth management as well as payment and settlement services. At the same time, banks made considerable efforts to strengthen corporate governance and enhance internal control processes. Therefore, it is worth to investigate the presence of economies of scale and scope in Macau's banking sector in view of the surging demand for banking services by the community. On the other hand, the research has already been done to estimate this important issue for banks in Mainland China and Hong Kong. Thus, this paper complements the existing studies on production economies by evaluating the production performance of the banking sector in Macau and sheds some light on enhancing the performance of Macau's banks through operational specialization/diversification and size expansion/reduction.

The banking industry, which is one of the four key industries driving economic development in Macau, accounted for, on average, around eight percent of Macau's GDP between 1995 and 2008. Except for two offshore banks, all of the banks in Macau are retail banks with full banking licenses. In March 2010, there were 24 fully licensed banks in Macau[2]. Ten were locally incorporated and 14 were branches of foreign

[1] For details, see Berger and Humphrey (1997) and Fu and Heffernan (2008).

[2] The postal savings office is excluded.

banks, with total bank deposits and assets of around MOP300 billion and MOP440 billion, respectively. The Monetary Authority of Macau (AMCM), which was created in 1989, is responsible for the formulation and implementation of monetary policy and the oversight of financial institutions in Macau.

The Financial System Act was introduced in 1993 along with a number of banking reforms to ensure the soundness of the banking system. The Act adopted the recommendations of the Basle Committee and various rules have been introduced since it was passed into law. For example, all Macau banks must meet minimum capital adequacy and liquidity ratios of 8.0% and 20.0%, respectively. The AMCM also issued a series of guidelines and rules concerning internal bank control and risk management in the 2000s to help Macau banks safely and prudently improve their financial performance, ensure their ability to maintain stability and enhance their capacity to combat risk.

On the other hand, the Financial System Act favors the introduction of the universal banking model. The Act allows banks in Macau to provide a wide range of products and services to their customers. These include accepting deposits and other repayable funds from the public; providing loans, guarantees and other commitments, financial leasing and factoring, and money transmission services; issuing and administering means of payment; conducting trading for their own account or for the account of their customers in money, financial and foreign exchange market instruments, and financial futures and options; participating in the issue and placement of securities and the provision of other services related to such issues; operating in interbank markets; as well as portfolio safekeeping, management of other assets, financial consultancy, safe custody services, and the sale of insurance contracts[1].

This paper employs the random effects panel data approach within a translog cost function framework to test for the presence of economies of scale and scope in Macau's banking sector and to assess whether any of the findings can be explained by differences in bank size and/or ownership. The paper is organized as follows. Section 1 reviews previous studies and section 2 discusses the methodologies employed and the data set. The results are reviewed in section 3. The final section discusses key conclusions and policy implications of the findings.

1. Literature review

There are two types of production economies that may be achieved by any firm – economies of scale and scope. Economies of scale are related to firm size and exist if average production costs decrease as output increases. Conversely, a firm displays diseconomies of scale if average production costs increase with output. Economies of scope are present if a firm can jointly produce two or more products and/or services at a lower cost than if they are produced separately. The cost of joint production is higher if there are diseconomies of scope (Baumol et al., 1982).

As indicated by Clark (1998), there are two potential sources of economies of scale and scope in banking. The first is the spreading of fixed costs. If excess capacity exists, fixed or quasi-fixed branch costs, labor costs, or computer and telecommunications equipment costs may be spread over large amounts of output and/or joint usage of these fixed resources. Information production is the second basis for economies of scale and scope. For example, the information collected from servicing a customer's deposits and loans may be 'reused'. As the cost of reusing information is usually less than the independent cost of its production, reuse may help reduce the incremental costs of extending additional services. According to Berger et al. (1987), there are two further sources of economies of scope: risk reduction and customer cost economies. Theoretically, asset diversification and asset-liability maturity matching can reduce portfolio and interest rate risks. To reduce risk in their revenue streams, banks may be willing to incur extra costs. In addition, when bank services are situated jointly, customer-incurred banking costs may be reduced due to transportation cost savings, and ease of inter-account fund transfers, etc.

The literature contains extensive research on the economies of scale and scope of banks in developed countries (Benston et al., 1982; Kim, 1986; Berger et al., 1987; Clark, 1988; Hunter and Timme, 1989; Shaffer, 1991; Berger and Humphrey, 1991; Mester, 1992; Zardkoohi and Kolari, 1994; Wheelock and Wilson, 2001; Rime and Stiroh, 2003). The results of these studies suggest that economies of scale exist only for small- and medium-sized banks. However, the findings for scope economies are inconclusive. Studies of emerging economies show, for example, economies of scale for small banks and economies of scope for all banks in the Ukraine (Mertens and Urga, 2001) and Singapore (Rezvanian and Mehdian, 2002). While the Pakistani banking industry exhibits economies of scale and scope, scale economies diminish for large banks. In addition, compared with public banks, private banks in emerging economies operate with relatively large economies of scale but small economies of scope (Iimi, 2004). The results of Fu and Heffernan (2008) indicate the presence of constant returns to scale and significant economies of scope for most joint-stock banks in China.

2. Methodology and data

2.1. Methodology. Banks are multi-product firms employing a vector of inputs to produce a vector of

[1] For details, refer to the official website of the AMCM (www.amcm.gov.mo).

outputs. Under duality theory, the multi-product cost function dual to the production function can be defined as:

$$C = f(Y, W), \tag{1}$$

where C is total cost, Y is a vector of outputs, W is a vector of input prices.

Following common practice, this study employs a parametric approach with a translog specification. The translog cost function takes the following form:

$$\ln C = \alpha_0 + \sum_p \beta_p \ln y_p + \sum_m \delta_m \ln w_m + \frac{1}{2}\sum_p \sum_q \beta_{pq} \ln y_p \ln y_q + \\ + \frac{1}{2}\sum_m \sum_n \delta_{mn} \ln w_m \ln w_n + \sum_p \sum_m \gamma_{pm} \ln y_p \ln w_m + \varepsilon, \tag{2}$$

where C is the total cost, y_p is the pth output, w_m is the mth input price, ε is the normally distributed random error term.

Standard symmetry ($\beta_{pq} = \beta_{qp}$, $\delta_{mn} = \delta_{nm}$) is imposed during estimation. To impose linear homogeneity restrictions on the function, all of the cost and input price terms are normalized by the last input price. Shephard's lemma[1] is not applied for either approach because it would impose the undesirable assumption that there are no allocative inefficiencies (Berger, 1993).

Overall scale economies (*SCALE*), also called ray scale economies, is developed by Baumol et al. (1982). *SCALE* is the elasticity of cost with respect to an output, holding output mix constant. It is defined as follows:

$$SCALE(Y) = \sum_p \partial \ln C(Y) / \partial \ln y_p, \tag{3}$$

where $C(Y)$ is the multiple-output cost function, Y is the vector of outputs $= [y_1 \cdots y_p]'$, p are the indexes of different products.

SCALE measures the percentage change in cost due to a one percent change in all outputs, a change that alters the scale of output but not output mix. *SCALE* < 1 implies economies of scale because costs increase proportionally less than outputs increase, while *SCALE* > 1 implies diseconomies of scale. *SCALE* is useful in cases where banks grow by changing their scales but not their output mix.

Obviously, *SCALE* does not allow for a change in output mix. Baumol et al. (1982) suggest an additional measure to illustrate how costs change when the output of one product changes while the quantities of all other products are held constant. Product-specific scale economies (*PSSE*) is present if an increase in the production of a specific product results in a decline in the average cost, holding the other outputs constant. However, Berger et al. (1987) argue that *PSSE* requires evaluation of the cost function at y_k near zero, which is generally far outside the sample over which the cost function is estimated. To remedy this problem, Mester (1992) defines a new measure of product-specific economies of scale, which is called within-sample product-specific scale economies (*WPSSE*). The within-sample degree of economies of scale specific to output k is:

$$WPSSE\ (y_k) = [IC(\tilde{y}_k) / C] / [\partial \ln C(Y) / \partial \ln y_k] \tag{4}$$

where

$$IC(\tilde{y}_k) = [C(y_1,...,y_p) - C(y_1,...,y_{k-1}, y_k^m, y_{k+1},...,y_p)],$$

where y_k^m is the sample minimum of y_k.

Thus, $WPSSE(y_k) > 1$ ($WPSSE(y_k) < 1$) implies economies (diseconomies) of scale in the production of the kth output[2]. Baumol et al. (1982) also develop overall scope economies (*SCOPE*), which measures the cost saving from joint versus specialized production. However, as the translog cost function is undefined for the zero output level required by *SCOPE*, Mester (1992) suggests a new measure where the minimum output within the sam-

[1] Shephard's Lemma was first introduced by R.W. Shephard in 1953. The cost function C is differentiable with respect to the components of the input price vector, w. Then the solution S to the cost minimization problem is unique and $S_m = \partial C / \partial w_m$, m = 1,…, N; i.e., the cost minimizing demand for the mth input is equal to the partial derivative of the cost function with respect to the mth input price. This result is known as the derivative property of the cost function, or Shephard's Lemma, as Shephard (1953) is the first to obtain the result.

[2] For some bank groups, the minimum levels of bank investments and non-interest income are zero. Following Mester (1992), in this section the minimum values of these outputs are the same as the conventional measures (0.001).

ple is substituted for the zero level inherent in *SCOPE*. Therefore, for the case of three outputs, the within-sample scope economies (*WSCOPE*) are defined as follows:

$$WSCOPE(Y^B) = [C(y_1^B - 3y_1^m, y_2^m, y_3^m) + C(y_1^m, y_2^B - 3y_2^m, y_3^m) + C(y_1^m, y_2^m, y_3^B - 3y_3^m) - \\ -C(y_1^B, y_2^B, y_3^B)] / C(y_1^B, y_2^B, y_3^B), \quad (5)$$

where y_p^m is the minimum value of y_p in the sample[1].

WSCOPE measures the percentage increase in the cost of dividing the outputs into relative specialized banks, though none more specialised than the most specialized bank in the sample. *WSCOPE* > 0, *WSCOPE* < 0, and *WSCOPE* = 0 suggest the presence of within-sample scope economies, scope diseconomies and scope neutrality respectively. *WSCOPE* is useful in cases where extreme product specialization is a viable business strategy (Mitchell and Onvural, 1996).

Another measure of economies of scope is product-specific scope economies (*PSCO*). *PSCO* exists if the cost of jointly producing one particular output with the existing output bundle is smaller than the sum of the cost of producing the output and the rest of the output bundle separately. To avoid the extrapolation inherent in the measure of *PSCO*, Mester (1992) suggests a new approach where the minimum output within the sample is substituted for the zero level of output. Thus, within-sample product-specific economies of scope (*WPSCO*) is developed and defined as:

$$WPSCO(y_k) = [C(y_1, ..., y_{k-1}, y_k^m, y_{k+1}, ..., y_p) + C(y_1^m, ..., y_{k-1}^m, y_k - y_k^m, y_{k+1}^m, ..., y_p^m) - \\ -C(y_1, ..., y_p)] / C(y_1, ..., y_p), \quad (6)$$

where y_k^m is the minimum level of output *k* within the sample.

Therefore, *WPSCO* is said to exist in the production of y_k when *WPSCO* (y_k) > 0, whereas *WPSCO* (y_k) < 0 indicates within-sample product-specific diseconomies of scope.

2.2. Data. The data set used in this study is collected from the annual financial statements of banks. The sample consists of 24 banks registered in Macau between 1995 and 2006. Their market share in terms of total assets was over 98% at the end of 2006. The intermediation approach is used to model the production process of the banking firm. Three outputs are identified, including total loans (y_1), investments (y_2), and other non-interest income (y_3) as a proxy for off-balance-sheet (OBS) activities. These outputs are produced using two inputs: borrowed funds (x_1) and other inputs (x_2)[2]. The unit price of funds (w_1) is computed by dividing the annual interest expenses by x_1. The price of other inputs (w_2) is calculated as the ratio of total non-interest expenses to x_2. Table 1 presents the descriptive statistics of these variables.

In details, Panel A shows the statistics for all sample banks. Panel B and Panel C illustrate the statistics for domestic and foreign banks, respectively. Domestic banks refer to banks incorporated in Macau. Foreign banks refer to banks incorporated outside Macau. There were 10 domestic banks and 14 foreign banks in Macau at the end of 2006. Focusing on the differences between Panel B and Panel C, it shows that the domestic banks produced slightly more outputs than their foreign counterparts in all three areas. However, the domestic banks could enjoy lower costs than those foreign banks on average. Finally, for domestic banks, the average unit price of funds was lower, whereas the average unit price of other inputs (e.g., fixed assets and labors) was higher comparing to the foreign players. Therefore, Table 1 presents a mixed picture on production economies of Macau banks.

Table 1. Descriptive statistics of Macau banks

Variable	Mean	Min	Max
Panel A: All banks			
Total cost	960,183.57	527.91	11,672,667.80
Loans	2,485,927.92	0.00001	31,599,825.65
Investments	1,347,697.21	0.00001	15,523,258.12
Other non-interest Income	37,988.99	1.01	489,402.70

[1] In this paper, ($y_p^B - 3y_p^m$) in equation (5) is substituted by ($y_p^B - y_p^m$) because, for the output vector y_1 (loans) and y_2 (investments), the value calculated by the former equation is negative, and hence cannot be used in the translog function to obtain costs. This may overestimate the costs of producing separately, or underestimate the costs of joint production. Hence, the results of *WSCOPE* should be interpreted with regards to this possible bias.

[2] "Other inputs" mainly include physical capital (fixed assets). Labor input is not considered because the number of employees is not available.

Table 1 (cont.). Descriptive statistics of Macau banks

Variable	Mean	Min	Max
Panel A: All banks			
Unit price of funds	0.036	0.002	0.131
Unit price of other inputs	1.521	0.152	18.758
Panel B: Domestic banks			
Total cost	833,612.76	527.91	990,537.76
Loans	2,697,564.11	0.00001	31,599,825.65
Investments	1,413,717.46	0.00001	15,523,258.12
Other non-interest Income	40,547.49	1.01	489,402.70
Unit price of funds	0.017	0.002	0.112
Unit price of other inputs	1.83	0.152	16.474
Panel C: Foreign banks			
Total cost	1,164,283.21	679.04	11,672,667.80
Loans	2,132,646.32	0.00001	19,644,732.4
Investments	1,262,126.94	0.00001	17,640,430.57
Other non-interest Income	33,018.33	1.01	322,993.5
Unit price of funds	0.049	0.003	0.131
Unit price of other inputs	1.357	0.194	18.758

Notes: All measures are in Macau pataca (thousands), except for unit costs.

3. Empirical results

Appendix to this paper reports the coefficients for estimating the translog cost function (equation (2)) using the random effects panel data approach. The use of these estimated coefficients together with the original data set produces different measures of economies of scale and scope. The results are presented in Table 2. Column (1) shows that overall scale economies (*SCALE*) and within-sample scope economies (*WSCOPE*) for the entire sample are statistically lower than one and higher than zero, respectively. This indicates that, on average, Macau banks have overall diseconomies of scale and economies of scope. This finding suggests that, while banks in Macau can generally obtain significant cost advantages through diversifying their asset portfolio, increasing size may lead to cost ineffectiveness.

Columns (2) to (4) provide information on the scale and scope economies for different size categories. Macau banks are divided into three groups in terms of total assets, including small, medium and large banks. As shown in Table 2, small and medium-sized banks exhibit decreasing returns to scale, whereas constant returns to scale cannot be rejected for large banks. This finding suggests the small and medium-sized banks should not expand their size under current techonology, whereas large banks have almost achieved their optimal scale, i.e., no more cost saving can be generated from expansion.

In addition, the results indicate that there are scope economies for banks in each of the three size categories. The magnitude of the scope measure, however, is greater for smaller banks than larger banks. This implication is consistent with previous studies of other countries (Rezvanian and Mehdian, 2002; Limi, 2004). That is, on average, Macau banks can reduce their cost of production through product diversification. The level of cost saving through portfolio diversification is larger for smaller banks than larger banks. We further divide the sample banks into domestic and foreign banks. Banks are categorized as domestic banks if they are incorporated in Macau. Otherwise, they are labelled as foreign banks. Columns (5) and (6) show that domestic and foreign banks exhibit significant diseconomies of scale and economies of scope. The difference in the magnitude of the scope measures suggests that the cost saving via asset diversification is larger for foreign banks than domestic banks.

Turning to the product-specific economies of scale (*WPSSE*) and scope (*WPSCO*), Column (1) shows that there are product-specific economies of scale with respect to total loans and diseconomies of scale with respect to other non-interest income, which is a proxy for OBS activities. This finding suggests that the marginal cost of producing loans falls short of its average cost. This further implies that the expansion of banks by increasing their loans is cost effective. The reverse is true for OBS activities.

Table 2. Economies of scale and scope

Types of scale and scope economies	Descriptions	(1) All banks	(2) Small banks	(3) Medium banks	(4) Large banks	(5) Domestic banks	(6) Foreign banks
SCALE	Overall scale economies	0.79***	0.56***	0.77***	0.98	0.89***	0.72***
WSCOPE	Within-sample scope economies	4.39***	7.41***	4.15***	2.71***	3.23***	5.29***
WPSSE(y_1)	Within-sample scale economies specific to y_1 (total loans)	4.17***	2.49	3.42***	5.82*	2.47**	5.46**
WPSSE(y_2)	Within-sample scale economies specific to y_2 (investments)	4.91	-3.57***	19.23	10.91	-15.45	20.49
WPSSE(y_3)	Within-sample scale economies specific to y_3 (other non-interest income)	-25.03**	-65.28**	7.24	-7.86	-18.33	-30.17
WPSCO(y_1)	Within-sample scope economies specific to y_1 (total loans)	11.71*	7.64***	37.85**	1.84**	1.77***	19.31**
WPSCO(y_2)	Within-sample scope economies specific to y_2 (investments)	17.42**	8.89***	48.95**	8.35***	5.93***	26.22*
WPSCO(y_3)	Within-sample scope economies specific to y_3 (other non-interest income)	19.59**	14.59***	47.86**	9.50***	8.01***	28.45**
NUMBER	Number of observations	256	77	83	96	111	145

Notes: Values with ***, ** and * are (1) statistically different from one for the measures of economies of scale (e.g., *SCALE* and *WPSSE*) and (2) statistically different from zero for the measures of economies of scope (e.g., *WSCOPE* and *WPSCO*) at 1%, 5% and 10% levels of significance, respectively. Small banks refer to banks with assets less than MOP1.2 billion. Medium banks refer to banks with assets ranging between MOP1.2 billion and MOP6.5 billion. Large banks refer to banks with assets over MOP6.5 billion. Domestic banks refer to banks incorporated in Macau. Foreign banks refer to banks incorporated outside Macau.

Focusing on banks of different sizes, Columns (2) to (4) show that large and medium-sized banks exhibit significant product-specific economies of scale with respect to loans, whereas there are significant product-specific economies of scope with respect to investment and OBS activities for small banks. These findings imply that large and medium-sized banks can save costs by increasing their loans. For small banks, however, expansion by increasing investments and OBS activities is cost ineffective. Finally, Columns (1) to (6) also show that there are significant product-specific economies of scope with respect to all three outputs regardless of bank size and ownership. This suggests that producing all outputs jointly is less costly than producing each output independently for all kinds of banks in Macau. The differences in the magnitudes of various product-specific scope measures further indicate that medium banks and foreign banks may enjoy greater cost advantage through asset diversification.

Conclusions

This paper is the first study to use banking data to examine the current economies of scale and scope in the Macau's banking sector. Using data collected for the period from 1995 to 2006, the random effects model with a panel data set is employed to estimate a translog cost function. Three major conclusions emerge from this study. First, in general, Macau banks exhibit diseconomies of scale and economies of scope. In particular, small and medium-sized banks face significantly decreasing returns to scale, while constant returns to scale is not rejected for large banks. On the other hand, economies of scope are greater for small- and medium-sized banks than large banks. These findings suggest that banks in Macau should diversify their asset portfolios to gain greater cost advantages, especially the small- and medium-sized banks. Meanwhile, it appears that operational expansion of these smaller banks should be discouraged under current technology because it is cost ineffective.

Second, large- and medium-sized banks exhibit significant product-specific economies of scale with respect to loans and there are significant product-specific economies of scope with respect to investments and OBS activities for small banks. Therefore, to save costs, larger banks should increase their loan assets in a safe and prudent manner and smaller banks should enhance their investments and OBS activities. Finally, our results show significant product-specific economies of scope with respect to all three outputs, regardless of bank size and ownership. This level of cost advantage is found to be greater for medium banks and foreign banks. These findings lend support to the implementation of the universal banking model in Macau, and the diversification of bank asset portfolios shoud be encouraged.

Overall, given the highly competitive environment in the banking sector and the increasing demand for diversified products and services by the customers, Macau policymakers shall encourage banks to make more efforts to broaden their sources of income in

several ways. Fee-based services should be further developed and enhanced, including mutual funds, unit trusts, securities, structured products, wealth management and other customized services for specific customers. Automated banking services in form of Internet banking, phone banking and mobile banking shall be widely applied to complement traditional banking services. Finally, besides the basic banking services (e.g., deposits, remittances and currency exchange) which have already been made available to the public, banks shall be encouraged to develop more services regarding Renminbi businesses in Macau.

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Appendix

Table 1A. Parameter estimates of the translog cost function

Variable	Coefficients	Std. error	z-value
Constant	29.00186***	4.14215	7.00
ln y_1	-0.34295	0.21314	-1.61
ln y_2	-0.09280	0.23690	-0.39
ln y_3	-1.29983***	0.46807	-2.78
ln w_1	1.20948***	0.41889	2.89
ln y_1 ln y_1 /2	0.00678	0.00622	1.09
ln y ln y_2	0.01097	0.00934	1.17
ln y_1 ln y_3	0.02331***	0.00890	2.62
ln y_2 ln y_2 /2	0.03059***	0.00461	6.64
ln y_2 ln y_3	-0.03443	0.02496	-1.38

Table 1A (cont.). Parameter estimates of the translog cost function

Variable	Coefficients	Std. error	z-value
ln y_3 ln y_3 /2	0.10276***	0.03405	3.02
ln w_1 ln w_1/2	0.02371	0.04145	0.57
ln y_1 ln w_1	0.04415***	0.00822	5.37
ln y_2 ln w_1	-0.03438***	0.01298	-2.65
ln y_3 ln w_1	-0.03797	0.02656	-1.43
R^2	0.91810		

Note: To impose linear homogeneity restrictions on the function, all of the cost and input price terms are normalized by the last input price, w_2.