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Relationship between sectoral employment and selected GDP components

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Abstract

Different sectors adjust their employment differently to changing economic conditions. This note quantifies the relationship between employment of major sectors and selected GDP components that represent developments in domestic and external markets. The long-run multipliers largely confirm the notion that employment in more externally-oriented sectors reacts to a greater extent to changes in external demand, and employment in more domestically-oriented sectors reacts more strongly to changes in spending in the domestic market.

不同行業就業人數與選定本地生產總值組成部分的關係

摘要

不同行業的就業人數對經濟情況轉變反應不同。本文量化主要行業的就業人數和反映本地和外圍市場發展的選定本地生產總值組成部分的關係。長期乘數大致確認了較為外向的行業的就業人數對外圍需求的變動較有反應；而較為面向本地的行業的就業人數則對本地市場消費的變動反應較大。

I. INTRODUCTION

1. Firms in different sectors of the economy naturally respond differently to changing economic conditions, including in terms of how many employees to hire or lay off. In particular, some firms are in more domestically-oriented sectors and their employment is more affected by spending in the local economy. Other firms are more externally-oriented and their employment is more affected by external conditions. The varied characteristics of these sectors, such as the ease of hiring and training new recruits and the cost of firing existing employees, warrant firms operating within to take different approaches to adjust their headcounts as local and external economic conditions change. This note uses cointegration analysis and an error correction model to quantify how employment in different major sectors in Hong Kong reacts to changes in local and external economic conditions.

II. DATA

2. Economic activities are expressed in terms of Gross Domestic Product (GDP), which measures the amount of goods and services produced by an economy within a given period. GDP data are compiled by the Census and Statistics Department (C&SD). In this note, the "consumption expenditure in the domestic market" (CXDM) component of GDP is used to gauge the situation in the domestic market that would affect the business performance of more domestically-oriented firms to a larger extent. CXDM measures the amount of goods and services purchased by residents and non-residents in the Hong Kong economy.

3. To investigate the degree to which employment by more externally-oriented firms is affected by external economic conditions, the "exports of goods and services" component of GDP is the variable of interest. While the entire "exports of goods" (XG) is relevant here and should be included, there is a component of tourist spending in "exports of services" (XS) which overlaps with the "expenditure of non-residents in the domestic market" in CXDM. Hence, to draw a clearer distinction between the indicators for the domestic and external markets, "non-tourism-related exports of services" (NTXS) is preferred to XS for the purpose of this analysis. Therefore, in the model to follow, CXDM, XG and NTXS will be used as regressors to explain the employment level of different sectors.

4. As for employment data, data from different major sectors in Hong Kong is sourced from C&SD's Quarterly Survey of Employment and Vacancies (SEV). The

SEV provides statistics on the number of persons engaged in private firms in the major sectors[1].

5. All the data for the analysis are of quarterly frequency and cover the period from 2000Q1 to 2019Q2. To abstract the effects of prices changes on the GDP components, the real series of GDP components are used. Seasonal adjustment with the X12-ARIMA method is also applied to the real series of GDP components and the series of sectoral employment to remove seasonal fluctuations[2]. Lastly, natural logarithms are used for the modelling so that the coefficient estimates can be interpreted as elasticities. The variables for the analysis are as follows:

Table 1: Dependent and independent variables of the model

	Variable name	Description
Dependent variable	LEMP_t	Employment of a sector at time *t* (in logarithms)
Explanatory variables	LCXDM_t	Consumption expenditure in the domestic market (CXDM) at time *t* (in logarithms)
	LXG_t	Exports of goods (XG) at time *t* (in logarithms)
	LNTXS_t	Non-tourism-related exports of services (NTXS) at time *t* (in logarithms)

III. METHODOLOGY

6. Since it takes time for firms to adjust their employment level to changes in economic conditions — i.e., current employment is affected by economic conditions in previous periods — an autoregressive distributed lag (ARDL) model is adopted. In an ARDL model, the regressors may contain lagged values of the dependent variable and the contemporaneous or lagged values of one or more explanatory variables.

7. A basic requirement of the ARDL model, as in any regression model, is that the data must be stationary. If not, the problem of spurious regression might occur, i.e. the estimated coefficients may be seemingly significant even though there is no actual underlying relationship between the variables. Augmented Dickey-Fuller tests, however, fail to reject the null hypotheses that the variables in **Table 1** are non-

[1] Major sectors covered by the SEV include import and export trade, wholesale, accommodation and food services and more. For a complete list of the sectors covered by SEV, please refer to the Quarterly Report of Employment and Vacancies Statistics published by C&SD.

[2] The seasonally adjusted series of the exports of goods (XG) is available from C&SD. The remaining seasonally adjusted series were prepared by the author.

stationary in levels but were able to reject the null that they are non-stationary in first differences[3]. This means that each of the series are I(1) (integrated of order one), i.e. non-stationary in levels and first differencing is required to turn each of them stationary.

8. First differencing the variables in **Table 1** before estimating the model is therefore the most obvious way to solve this problem of spurious regression. However, this approach has its drawbacks because it removes long-run information. Another possibility, if a cointegrating (long-run) relationship between the variables exists, is to use cointegration analysis. There are different tests for the existence of such a relationship. Pesaran, Shin and Smith (2001) proposed an ARDL approach to cointegration testing[4] which can be applied to I(1) variables, I(0) variables, or a mixture of both types. Since the data are all I(1), their test can be used here.

9. For each sector, to test if there is any cointegrating relationship between employment and the GDP components, an ARDL model has to be specified. The determination of the lag structure of the model is usually based on minimizing a selection criterion such as the Akaike Information Criterion (AIC) or the Bayesian Information Criterion (BIC). In this note, the AIC is used for choosing the optimal number of lags, with a cap of two for the lag dependent variable and a cap of four for the other regressors. A time trend is also included to account for changes in employment due to changes in productivity. Therefore, for each sector, the following model is specified:

$$\mathrm{LEMP}_t = \beta_0 + \beta_1 t + \sum_{i=1}^{p} \beta_{EMP,i}\mathrm{LEMP}_{t-i} + \sum_{i=0}^{q} \beta_{CXDM,i}\mathrm{LCXDM}_{t-i} + \sum_{i=0}^{r} \beta_{XG,i}\mathrm{LXG}_{t-i} + \sum_{i=0}^{s} \beta_{NTXS,i}\mathrm{LNTXS}_{t-i} + u_t \quad \textbf{---- (Equation 1)}$$

where *p, q, r* and *s* are respectively the numbers of lags selected by the AIC;
t is the deterministic time trend; and
u_t is the error term at time *t*.

10. To test for the presence of cointegration, the ARDL model above **(Equation 1)** is rewritten in an unrestricted error correction form[5]:

[3] The lags were chosen by minimizing Bayesian Information Criterion (BIC) with a cap of 4.

[4] Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289–326.

[5] An *unrestricted error correction model* is the same as a conventional error correction model except that the cointegrating terms (i.e. in this case LEMP, LCXDM, LXG and LNTXS) are not restricted. It is referred to as a *conditional error correction model* in Pesaran, Shin and Smith (2001).

$$\Delta \mathrm{LEMP}_t = \beta_0 + \beta_1 t + \alpha_0 \mathrm{LEMP}_{t-1} + \alpha_1 \mathrm{LCXDM}_t + \alpha_2 \mathrm{LXG}_t + \alpha_3 \mathrm{LNTXS}_t + \sum_{i=1}^{p-1} \gamma_{EMP,i} \Delta \mathrm{LEMP}_{t-i} + \sum_{i=0}^{q-1} \gamma_{CXDM,i} \Delta \mathrm{LCXDM}_{t-i} + \sum_{i=0}^{r-1} \gamma_{XG,i} \Delta \mathrm{LXG}_{t-i} + \sum_{i=0}^{s-1} \gamma_{NTXS,i} \Delta \mathrm{LNTXS}_{t-i} + u_t$$ **--- (Equation 2)**

where $\alpha_0 = -(1 - \sum_{i=1}^{p} \beta_{EMP,i})$, $\alpha_1 = \sum_{i=0}^{q} \beta_{CXDM,i}$, $\alpha_2 = \sum_{i=0}^{r} \beta_{XG,i}$, and $\alpha_3 = \sum_{i=0}^{s} \beta_{NTXS,i}$.

For each sector, Pesaran, Shin and Smith's (2001) bounds test for cointegration is an F-test of the following null hypothesis:

$$H_0: \alpha_0 = \alpha_1 = \alpha_2 = \alpha_3 = 0$$

The test statistic is then compared to two critical values. If it is greater than the upper critical value[6], the null of no cointegration can be rejected. If it is between the lower and upper critical values, the test is inconclusive. If it is smaller than the lower critical value, the null of no cointegration cannot be rejected.

11. If a cointegrating relationship between the variables is found, **Equation 2** can be written in the following conventional error correction form:

$$\Delta \mathrm{LEMP}_t = \beta_0 + \beta_1 t - \alpha(\mathrm{LEMP}_{t-1} - \theta_{CXDM} \mathrm{LCXDM}_t - \theta_{XG} \mathrm{LXG}_t - \theta_{NTXS} \mathrm{LNTXS}_t) + \sum_{i=1}^{p-1} \gamma_{EMP,i} \Delta \mathrm{LEMP}_{t-i} + \sum_{i=0}^{q-1} \gamma_{CXDM,i} \Delta \mathrm{LCXDM}_{t-i} + \sum_{i=0}^{r-1} \gamma_{XG,i} \Delta \mathrm{LXG}_{t-i} + \sum_{i=0}^{s-1} \gamma_{NTXS,i} \Delta \mathrm{LNTXS}_{t-i} + u_t$$ **--- (Equation 3)**

where $\alpha = -\alpha_0$, $\theta_{CXDM} = \alpha_1/\alpha$, $\theta_{XG} = \alpha_2/\alpha$, and $\theta_{NTXS} = \alpha_3/\alpha$.

In this equation, α can be interpreted as the speed of adjustment and represents the amount of disequilibrium in employment in one period that is corrected for in the next. θ_{CXDM}, θ_{XG} and θ_{NTXS} in the cointegrating relationship are the long-run multipliers and they measure the effect of a permanent change in the regressor on the dependent variable. Since the data are expressed in logarithms, these long-run multipliers can be interpreted as long-run elasticities. For example, θ_{CXDM} measures the long-run elasticity of employment in a sector with respect to CXDM.

[6] The critical values from Pesaran, Shin and Smith (2001) are for sample sizes of 1000. This note uses critical values calculated for sample sizes between 30 and 80 from Narayan (2005), which are readily available from statistical software.
Narayan, P. K. (2005). The saving and investment nexus for China: evidence from cointegration tests. *Applied Economics, 37*(17), 1979–1990.

III. RESULTS

12. The results of the bounds test show that for each sector, the null hypothesis of no cointegrating relationship is rejected at the 5% significance level or higher. These results are verified to be unbiased as the Breusch-Godfrey test for serial correlations showed that there was little evidence of serial correlation in the residuals of **Equation 2** for each sector.

13. Since it has been shown that there is a cointegrating relationship for each sector, the conventional error correction model **(Equation 3)** is estimated for each sector. **Table 2** shows the estimates of the cointegrating relationship (whose coefficients are the long-run multipliers), along with the estimates of a simpler model $\text{LEMP}_t = \beta_0 + \beta_1 t + \beta_{CXDM}\text{LCXDM}_t + \beta_{XG}\text{LXG}_t + \beta_{NTXS}\text{LNTXS}_t + u_t$ **(Equation 4)** for comparison[7]. The estimates of the error correction terms are shown in **Table 3**.

Table 2: Estimates of the cointegrating relationships between sectoral employment (in logarithms) and selected GDP components (in logarithms)

Sector of employment	Consumption expenditure in the domestic market (LCXDM)		Exports of goods (LXG)		Non-tourism-related exports of services (LNTXS)	
	ECM (Eq. 3)	FMOLS (Eq. 4)	ECM (Eq. 3)	FMOLS (Eq. 4)	ECM (Eq. 3)	FMOLS (Eq. 4)
Import/export trade and wholesale	0.199 (0.113)	0.162** (0.054)	0.201** (0.051)	0.159** (0.043)	0.023 (0.039)	-0.016 (0.034)
Information and communications	0.887** (0.062)	0.547** (0.068)	-0.025 (0.031)	-0.058 (0.054)	-0.265** (0.022)	-0.231** (0.043)
Retail, accommodation and food services	0.871** (0.089)	0.789** (0.051)	-0.049 (0.059)	-0.115** (0.041)	0.060 (0.035)	0.055 (0.032)
Financing, insurance, real estate, professional and business services	0.662** (0.075)	0.656** (0.044)	-0.062 (0.046)	-0.115** (0.036)	0.112** (0.031)	0.103** (0.028)
Social and personal services	0.142 (0.088)	-0.072 (0.054)	-0.049 (0.051)	-0.056 (0.043)	0.173** (0.040)	0.202** (0.034)
Transportation, storage, postal and courier services	0.404** (0.099)	0.219** (0.043)	-0.042 (0.046)	-0.078* (0.034)	0.115** (0.034)	0.105** (0.027)

Note: ** and * denotes significance at the 1% and 5% levels respectively. Standard errors are in parentheses.

[7] Since a cointegrating relationship was established, Phillips and Hansen's (1990) fully modified OLS model could be used to estimate **Equation 4**. The coefficient estimates of **Equation 4** are roughly in line with those of **Equation 3**, in the sense that where statistical significances of estimates do not agree, the 95% confidence interval of the estimate of one model contains the point estimate of the other model, and vice versa.
Phillips, P. & Hansen, B. (1990). Statistical inference in instrumental variables regression with I(1) processes. *Review of Economic Studies*, *57*(1), 99-125.

Table 3: Estimates of the error correction terms by sector

	Error correction term (-α)
Import/export trade and wholesale	-0.259** (0.050)
Information and communications	-0.618** (0.056)
Retail, accommodation and food services	-0.352** (0.072)
Financing, insurance, real estate, professional and business services	-0.329** (0.040)
Social and personal services	-0.297** (0.059)
Transportation, storage, postal and courier services	-0.335** (0.064)

Note: ** denotes significance at the 1% level. Standard errors are in parentheses.

14. From **Table 2**, it can be seen that the long-run elasticities of employment in most sectors with respect to consumption expenditure in the domestic market are significant. In particular, the employment elasticities of "information and communications", "retail, accommodation and food services" and "financing, insurance, real estate, professional and business services", which are respectively 0.89, 0.87 and 0.66, are relatively large. This indicates that these sectors, especially the former two, adjust their employment more readily to changes in consumption spending in the domestic market.

15. On the other hand, some sectors adjust their employment less strongly to changes in consumption expenditure in the domestic market. The long-run elasticity of employment in "transportation, storage, postal and courier services" with respect to consumption expenditure in the domestic market is relatively small at 0.40, indicating that this sector adjusts its headcount less readily to changes in local consumption than other sectors. The corresponding long-run elasticities for "import/export trade and wholesale" and "social and personal services" are even smaller, suggesting that changes in consumption sentiment in the local economy should not affect employment of these two sectors much.

16. Out of all the selected sectors, only "import/export trade and wholesale" has a relatively large long-run elasticity of employment with respect to exports of goods (0.20) as this sector is more externally-oriented. On the other hand, the long-run elasticities of non-tourism-related exports of services on employment are generally small and positive for different sectors except for "information and communications" whose associated elasticity is negative. However, since the size of this sector is relatively small compared to those sectors for which the corresponding elasticities were both

positive and significant[8], a change in non-tourism-related exports of services should have a positive impact on overall employment of the selected sectors.

17. In **Table 3**, the speed of adjustment refers to the $-\alpha$ coefficient in **Equation 3**. The negative and highly significant values of this parameter, as seen for all sectors, conform to the notion that it takes time for firms to adjust employment in response to changes in economic conditions. For most sectors, the absolute values of the speed of adjustment range from 0.25 to 0.35, which suggests that one fourth to one third of disequilibrium in one quarter is corrected for in the next, and that it takes about three to four quarters for employment in these sectors to return to equilibrium after a deviation from it.

IV. CONCLUDING REMARKS

18. This note uses an error correction model to quantify the relationship between employment in major sectors and selected GDP components that represent developments in domestic and external markets. It is found that a cointegrating relationship exists between employment, consumption expenditure in the domestic market, exports of goods and non-tourism-related exports of services for all sectors in the analysis. The long-run multipliers largely confirm the notion that employment in more externally-oriented sectors reacts to a greater extent to changes in external demand, and employment in more domestically-oriented sectors reacts more strongly to changes in spending in the domestic market.

[8] In 2018, "information and communications" employed about 110,000 persons. On the other hand, "financing, insurance, real estate, professional and business services", "social and personal services" and "transportation, storage, postal and courier services" employed about 750,000, 520,000 and 180,000 persons respectively.