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Thammasat Review of Economic and Social Policy

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Our journal is dedicated to serve as a platform for debate and critical discussion pertaining to the current issues of public policy. The outcome of such research is expected to yield concrete policy implications. Some of the targeted issues include urban and regional socio-economic disparities, ageing society, healthcare, education and welfare policies, environmental and natural resources, local communities, labor migration, productivity, economic and political integration, political economy, macroeconomic instability, trade and investment, fiscal imbalances, decentralization, gender issues, behavioral economics and regulations; and law and economics. The journal makes its best effort to cater a wide range of audience, including policymakers, practitioners in the public and business sectors, researchers as well as graduate students.

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Thammasat Review of Economic and Social Policy

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Invited Article

Research Articles

Editorial Introduction

Since the beginning of 2020, the spread of COVID-19 has impacted people from all walks of life with varying degrees of magnitude and dimension. For Thailand, domestic demands are constrained, especially in the sectors related to tourism. Following the re-opening of the cities from several shut downs, small and medium enterprises (SMEs) will have to adjust substantially. Business models need considerable modification to suitably meet the post-COVID-19 demands. This also implies the urgency of government assistance on the purchasing power as well as efficient policy measures to ensure subsistent funding for sustainable recovery.

This issue contains a well-diversified combination of quality research findings that have important policy implications. Specifically, in this issue, we are honoured to begin with the invited article, "Synergizing Economic Growth and Financial Stability: The Role of Banking Institutional Setup in Thailand" contributed by Somprawin Manprasert and Kongphob Wongkaew. This is a timely investigation of the Thai banking system and its role in the Thai economy. The authors examine the lending pattern of the corporate credit market in Thailand, comparing it with lending patterns across different groups of countries. They find that banks in Thailand appear to be risk-averse and are providing insufficient credit to SMEs and to businesses for investment purposes. They believe that this has led to a divergence between the banking sector and the real economy.

As a result of their research, the authors suggest that it would be beneficial for banks, and for the economy, if the banking system were to put greater emphasis on financial inclusion in the form of increased lending for investment and to SMEs. The authors argue that banks would benefit from diversifying their portfolio, and in turn, as firms are equipped

with better tools for economic and financial risk management, the broader economy will be more resilient to shocks. Using the example of French banking in the 1980s, the authors advocate for regulation to ensure that the Thai banking sector is more competitive, and that market power is more equally distributed among banks. This, the authors believe, along with greater emphasis on financial inclusion, should lead to a competitive and innovative banking sector better able to support the Thai economy.

The second article, "Technical Efficiency of Private Clinics Under Universal Coverage Scheme in Bangkok, Thailand" by Pimpitcha Kangyang and Paitoon Kraipornsak looks at the performance of private clinics which have partnered with the Government of Thailand to provide healthcare under the Universal Coverage Scheme. The article measures the technical efficiency of private clinics under the scheme and attempts to identify the factors which affect efficiency using a Tobit regression model. Existing data on 88 private clinics operating in Bangkok under the scheme were examined. The findings show that a majority of clinics were performing at or near the efficiency frontier. Efficiency in this case is defined as the number of outpatient visits and health promotion and prevention visits given staff costs, operating expenses, and building and equipment expenses.

The authors then employed a Tobit regression model to identify the factors which had the most impact on efficiency. The research finds that the most significant factor on efficiency is the health supporting staff ratio. The authors suggest that, in order to improve the level of health care offered under the scheme, clinics operating at or near the efficiency frontier as identified in the paper should consider expanding their operations. Moreover, clinics should also increase the health supporting staff ratio.

The third article, "How Subjective Well-Being and Physical Health Are Linked: Mediation Analysis" by Prompong Shangkhum and Dusanee Kesavayuth, analyse the effects of physical activity, social interaction, smoking, alcohol consumption, outdoor tasks, and volunteer or charity work on physical and mental health. In particular, the authors look at how such activities affect physical health and subjective well-being. The paper proposes a mediation framework which attempts to analyse the relationship between subjective well-being and physical health. The analysis employs thirteen waves of Household, Income and Labour Dynamics in Australia (HILDA) Survey. Particularly, the analysis employs individuals who have participated in all thirteen waves of the survey to account for the possibility that individuals suffering from poor mental health may self-select to drop out of the survey.

Using extensive and detailed data, the authors estimate a random effect and fixed-effect panel regressions in order to identify the direct and indirect effects of the mediators of subjective well-being and physical health. The results show that there is a significant relationship between mental health and physical health, with physical activity being the main mediator, suggesting that happy people tend to engage more often in physical activity which positively influences their physical health. Building on this result, the authors suggest that, in the interest of public health, governments should pursue policies that promote physical activity to directly improve physical health, and indirectly through its positive effect on mental health.

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TRESP seek to provide an effective platform for reflecting practical and policy-oriented perspectives that links the academic and policymaking community. There are no submission and publication fees. However, the submitted manuscripts must be policy relevant and comply with the scope and requirements of the journal. Authors are responsible for the published articles. The views and opinions expressed in the articles do not necessarily reflect those of the Editors and the Editorial Board. For further information and updates on this journal, or to submit an article, please visit our website at:
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and http://www.tresp.econ.tu.ac.th
The next issue, Volume 7, No. 2, onwards also welcomes our new Editor-in-Chief, Dr. Pornthep Benyaapikul.

Euamporn Phijaisanit
Editor-in-Chief

Thammasat Review of Economic and Social Policy
Volume 7, Number 1, January – June 2021

Invited Article

Synergizing Economic Growth and Financial Stability: The Role of Banking Institutional Setup in Thailand[1]

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[1] All opinions expressed are personal and do not necessarily represent the view of Bank of Ayudhya PCL and Waseda University. The authors are grateful to Professor Euamporn Phijaisanit for her valuable comments and suggestions.

ABSTRACT

The Thai banking system has contributed less to economic growth and has become more detached from the real economy in recent years. We find that Thailand's bank credit market has been distorted, with banks providing restricted corporate credit for new establishments and investments, particularly for SMEs. This article discusses the underlying reasons for low corporate lending and a distorted credit market. We demonstrate that the Thai corporate credit market has been constrained by inadequate credit supply for more than three-fourths of the time between 2010 and the third quarter of 2020. Additionally, we find that loan approval decisions have been substantially weighted toward risk. Then, we examine the link between credit inclusion and credit risk, highlighting the opportunity for the Thai banking system to benefit from the synergy between credit inclusion and risk management. The result implies that the Thai banking system should put more emphasis on credit inclusion. Finally, we seek to give remedies via the lens of new institutional economics from a historical viewpoint. That is, the regulator must prevent overprotection and encourage more competition within the banking industry.

Keywords: Economic Growth, Financial Stability, Credit, Banks, New Institutional Economics

JEL Classification: B52, E51, E58, G21

1. Introduction and Stylized Facts

Well-functioning financial systems are important in achieving sustained economic growth. They play a crucial role in channeling household savings into the corporate sector and allocating investment funds among firms.

Toshihiko Fukui
The 29th Governor of the Bank of Japan and a former director of the Bank for International Settlements (BIS)[2]

The financial system has played prominent roles in supporting and sustaining economic growth across the world. The quote mentioned above establishes the fundamental function of the financial system: to intermediate and help allocate financial resources. Financial intermediaries and financial markets possess specific technology and expertise to overcome information asymmetry between lenders and borrowers. As the world economy has increasingly matured and connected, the financial system has also provided instruments and services that help mitigate the detrimental consequences of the unprecedented economic shocks and their propagations.

But does the empirics suggest so? It seems not the case for the Thai economy. Table 1 indicates that, since the end of the 2008-2009 Global Financial Crisis (GFC), the Thai financial system has exhibited more solid and steady growth than the real sector, and this gap has been growing more pronounced over time. The recent COVID-19 pandemic confirmed our observations as Figure 1 indicates that the Thai financial sector has been much more resilient to the pandemic shocks than the

[2] Opening Speech at the 11th International Conference sponsored by the Institute for Monetary and Economic Studies, Bank of Japan, on July 5, 2004

real economy. This evidence implies that the Thai financial system has increasingly decoupled from the real economy and has contributed less to economic growth.

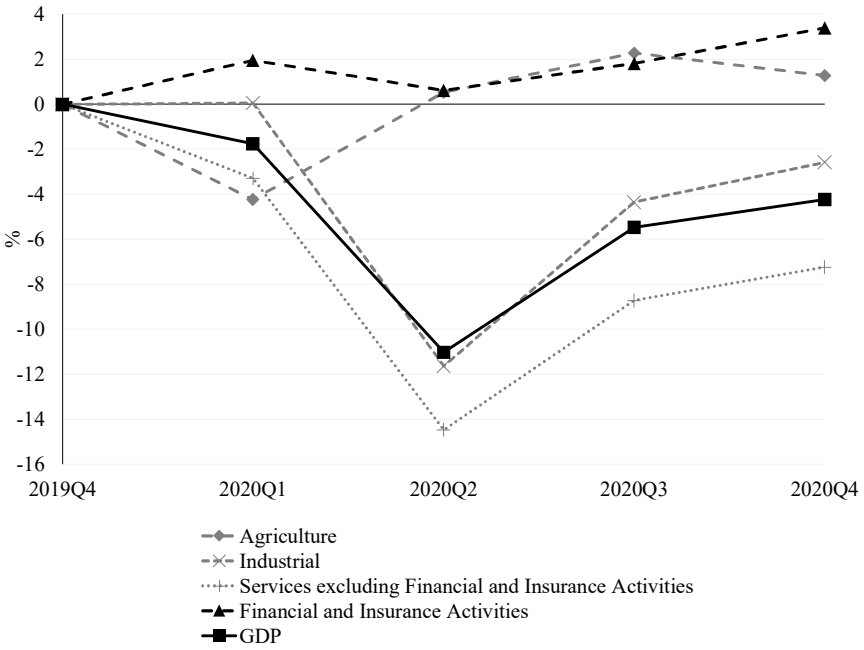
Table 1. Mean and standard deviation of Real GDP growth rates

Year-Over-Year Growth Rate (%)	All observation		1994-2000		2001-2009		2010-2020	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Agriculture	2.18	6.05	3.94	7.36	2.44	5.53	0.84	5.30
Industrial	3.68	6.07	4.80	6.64	5.12	4.26	1.79	6.57
Services excl. Financial and Insurance Activities	3.57	4.32	3.32	5.53	3.94	2.78	3.43	4.56
Financial and Insurance Activities	3.15	12.34	-7.06	19.06	6.51	6.96	6.91	4.41
Gross Domestic Product	3.33	4.45	2.95	6.07	4.31	2.83	2.78	4.29

Source: Office of the National Economic and Social Development Council

The natural question arises: where precisely does this decoupling take place? We found that the decoupling arises in the bank credit market, the external funding source on which Thai households and firms rely the most. We explore and compare the Thai bank credit market structure with international peers and detect many structural imbalances. We suspect that these imbalances could indicate market distortions attributable to the decoupling. The imbalances can be categorized into four groups as follows.

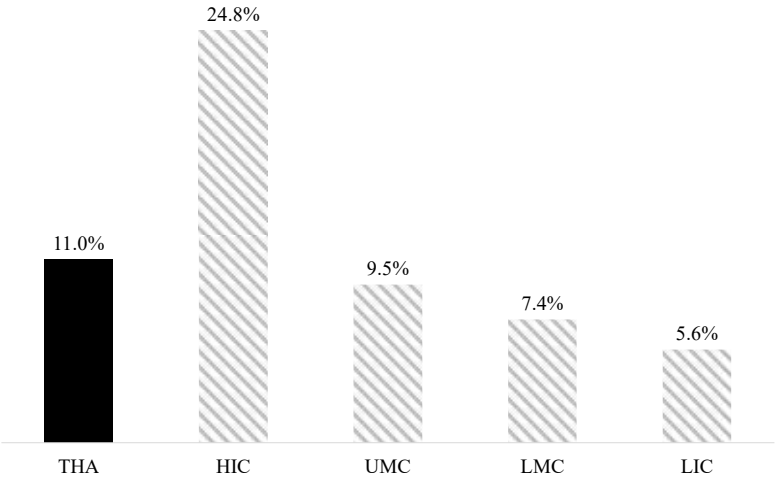
Figure 1. Real GDP Development since the fourth quarter of 2019



Source: Office of the National Economic and Social Development Council

First, Thai firms have received relatively limited credit for the establishment, operation, and expansion of business. The World Bank's Global Findex survey in 2017 suggests that only 11% of the Thai population of age 15 or above had access to credit to start, operate, or expand a business. This number is less than half of the high-income countries' number (Figure 2).

Figure 2. Percentage of respondents who report borrowing any money to start, operate, or expand business

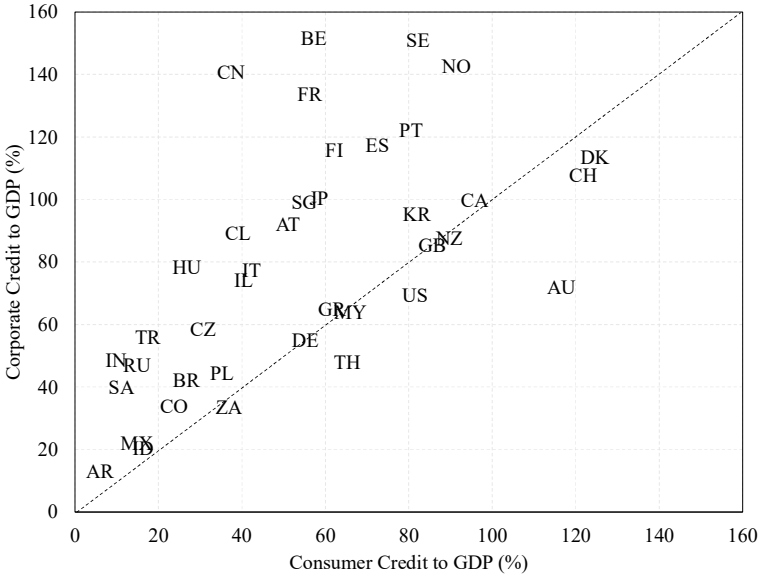


Note: The percentage of respondents of age 15 or above who report borrowing any money to start, operate, or expand a farm or business in the past 12 months. The data is the most recent values over the period 2009–2017. THA, HIC, UMC, LMC, and LIC refer to Thailand, the average of high-income countries, upper-middle-income countries, lower-middle-income countries, and low-income countries, respectively.
Source: Global Findex Database 2017, World Bank

Second, Thai credits are skewed heavily towards consumer credits, while corporate credits are subdued. Figure 3 suggests that most countries were characterized by higher corporate credit to GDP ratio than consumer credit to GDP ratio during 2010-2018. On the other hand, the Thai consumer credit (65.24%) notably exceeded the corporate credit to GDP ratio (48.28%). The Thai corporate credit to GDP ratio is lower than other countries from the same per-capita income groups, such as Malaysia (64.18%) and Turkey (56.13%). Thailand's ratio is even far below high-income countries such as Canada

(99.87%), France (133.90%), and Belgium (151.83%). In fact, consumer and corporate credits are essential for different purposes. Consumer credits facilitate the intertemporal income allocation to smooth lifetime consumption.

Figure 3. Relative size of consumer credit and corporate credit across countries

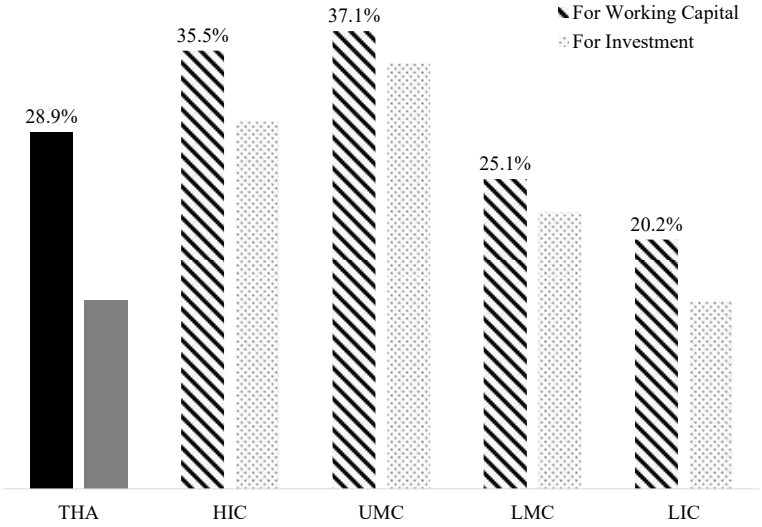


Note: Average values over the period 2010–2018.
Source: Bank of International Settlements

On the other hand, corporate credit allows firms to invest and better manage working capital. The evidence, however, signals that the distribution between consumer and corporate credits is suboptimal. We conjecture that the inflated consumer credit is attributable to the distortive institutional design, which grants easy access to consumer credit. For example, Thai firms can easily access consumer loans and credit cards and use them for business purposes without adequate

monitoring or restriction from banks. Since the lending rate on consumer credit is higher than corporate credit, these borrowers incur additional costs and are deemed cost-inefficient.

Figure 4. Percentage of firms who report using banks loans to finance working capital / purchases of fixed assets



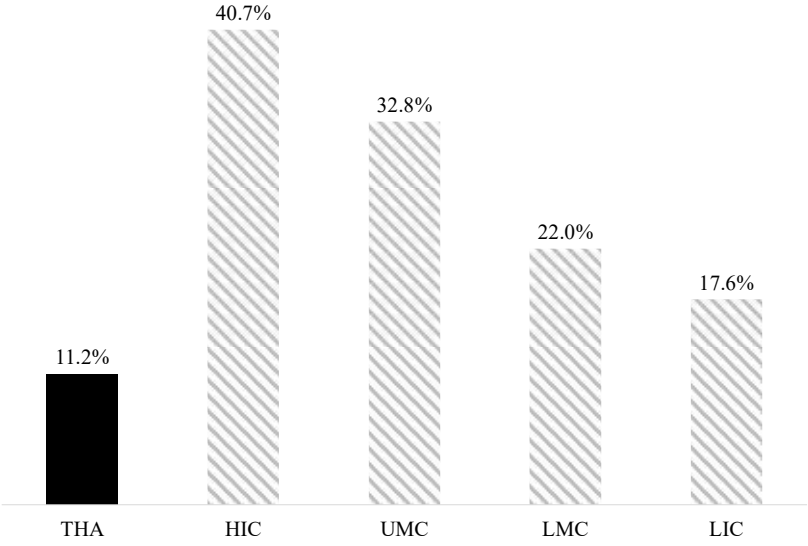
Note: Corporate credit for working capital refers to the percentage of firms using banks loans to finance working capital. Corporate credit for investment refers to firms using banks loans to finance purchases of fixed assets. The data is the most recent values over the period 2009–2017. THA, HIC, UMC, LMC, and LIC refer to Thailand, the average of high-income countries, upper-middle-income countries, lower-middle-income countries, and low-income countries respectively.
Source: Global Financial Development Database, World Bank

Third, Thai corporate credit is characterized by excessive credit for working capital but limited credit for investment. In 2017, around 28.9% of surveyed Thai firms reported using bank credits to finance working capital (Figure 4). On the

contrary, only 15.3% have access to bank credits to finance investment. Thailand's investment credit ratio is indifferent to the average ratio of low-income countries.

Fourth, access to corporate credit has been even more subdued for small enterprises. A recent survey from the World Bank's Global Financial Development Database suggests that only 11.2% of small Thai firms in 2016 have access to credit from formal financial institutions (Figure 5).

Figure 5. Percentage of small firms (5-19 workers) in the formal sector with a line of credit or a loan from a financial institution



Note: The data is the most recent values over the period 2009–2017. THA, HIC, UMC, LMC, and LIC refer to Thailand, the average of high-income countries, upper-middle-income countries, lower-middle-income countries, and low-income countries respectively.
Source: Global Financial Development Database, World Bank

Compared to other countries, the Thai economy is far behind the average among high-income countries (40.7%) and upper-middle-income countries (32.8%) during 2009-2017. The Thai economy is even lacking behind the average among low-income countries (17.6%).

These four imbalances share a common inconvenient story: the Thai credit market is distorted. More importantly, Thai banks have provided limited corporate credit for new establishments and new investment purposes, especially for SMEs.

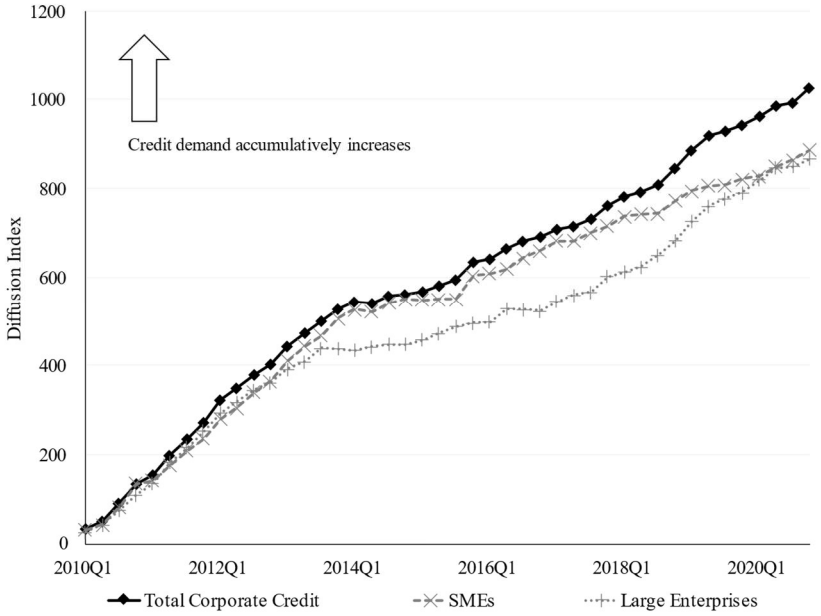
Motivated by these observations, this paper attempts to explain the causes of bank credit market distortion and subdued corporate credit. We first identify the corporate credit market disequilibrium and review the bank's incentives and the credit approval process. Then, we attempt to interpret the results through the framework of institutional economics. We present the opportunity for the Thai banking system to achieve better synergy between credit inclusion and credit risk within the Thai corporate credit market. Lastly, we attempt to provide the general solution from an institutional economics perspective.

The rest of this paper is organized as follows. Section 2 provides evidence of corporate credit market disequilibrium and layout potential determinants. Section 3 documents the synergy between credit access and credit risk from cross-country evidence and locates the choice of Thai banking system. In Section 4, we propose an institutional framework to achieve better combination of credit inclusion and financial stability. Section 5 concludes.

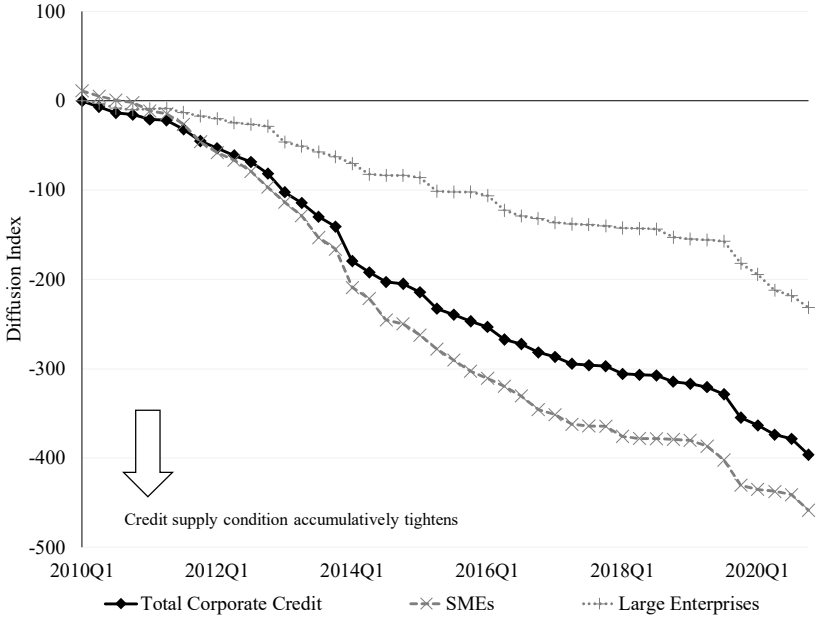
2. Corporate Credit Market Disequilibrium: Thai corporate credit is insufficient

Is corporate credit insufficient? This section investigates whether limited corporate credit is demand-driven or supply-driven. We resort to credit demand and supply conditions from banks' perspective as the proxies of the actual conditions. We utilize the Bank of Thailand's Senior Loan Officer Survey, which provides the views of senior loan officers from banks, credit card providers, and personal loan companies regarding the actual and expected credit demand and supply conditions. Preliminary observation points to persistent excess demand of corporate credit: credit demand has accumulated continuously since the first quarter of 2010. Nonetheless, financial institutions have kept raising credit standards, especially for the credit to SMEs (Figure 6).

Figure 6. Credit demand and supply condition



(a) Accumulative credit demand condition



(b) Accumulative credit standard
Note: Diffusion Index (DI) format ranges between -100 and 100.

Source: Senior Loan Officer Survey, Bank of Thailand

We adopt Maddala and Nelson (1974)'s model of markets in disequilibrium (MN henceforth) to estimate the time series of excess demand (supply) of corporate credit in Thailand. MN provided the parsimonious model of credit demand, credit supply, and the observable credit equilibrium. The advantages of the MN model are that it is well-specified to utilize the data-embedded information regarding excess demand (supply) of credit, and also allow us to estimate the probability with which the credit market in a particular point in time belongs to excess demand or excess supply regime. The model consists of the following equations:

$$D_t = \alpha_0 + \alpha_1 DEMANDSURVEY + u_{1t}, \quad (1)$$

$$S_t = \beta_0 + \beta_1 SUPPLYSURVEY + u_{2t}, \quad (2)$$

$$Q_t = \min(D_t, S_t), \quad (3)$$

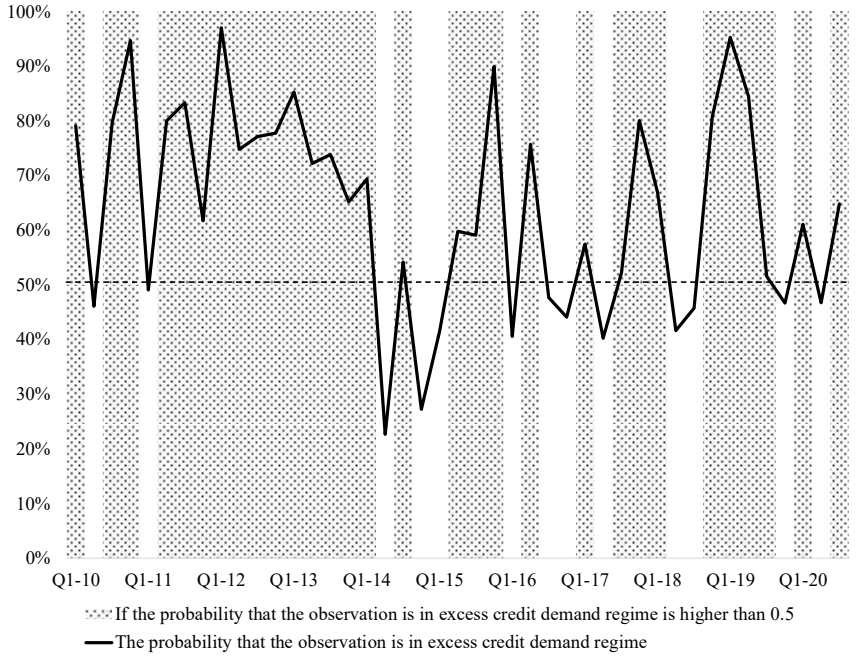
where D_t denotes the credit demand at t, S_t denotes the credit supply at t, $DEMANDSURVEY$ denotes credit demand condition in bank's view, $SUPPLYSURVEY$ denotes credit supply condition in bank's view, and Q_t denotes the observed net new credit at t. We assume that u_{1t} and u_{2t} are independently and normally distributed with zero means and constant variances σ_1^2 and σ_2^2 respectively, and they are independent from each other. Given the estimated results, we can obtain the probability that the observable net new credit Q_t belongs to the excess demand regime as

$$\pi_t = \Pr(D_t > S_t). \quad (4)$$

We estimate our model with Maximum Likelihood methods, where we derive the likelihood function from the unconditional density of Q_t and the conditional density of Q_t on that Q_t belongs to the excess demand regime. We adopt the OLS estimated coefficient values as initial parameter values. For the net new corporate credit data, we resort to the actual corporate credit data provided by the Bank of Thailand. The sample period covers the first quarter of 2010 to the third quarter of 2020.

Figure 7 presents the estimated probability that the observable net new credit Q_t at time t belongs to the excess demand regime. The estimation shows that the Thai corporate credit market has experienced excess demand for credit for 30 quarters of total 43 quarters, which is 73% of the sample period. We conclude that corporate credit is constrained from the supply side, and is insufficient compared to credit demand.

Figure 7. The estimated probability that the observable net new credit belongs to the excess demand regime



Source: Authors' Calculations

Now, we further investigate the rationale behind constrained corporate credit supply. According to Shekhar and Shekhar (1974), a bank allocates credit across borrowers to maximize the risk-adjusted return from lending. From the theoretical and empirical literature, we established three groups of corporate credit supply's determinants[3]. The first group of determinants is a borrower's return and risk profile. The bank collects and examines the borrower's return and risk

[3] For theories, refer to Shekhar and Shekhar (2013), and Heffernan (2005). For empirical analyses, refer to Kishan and Opiela (2000), and Jiménez, Ongena, Peydró, and Saurina (2012).

from the company's financial history, financial statements, and business plan. The bank also considers the economic factors at the sectoral and macroeconomic level, such as sectoral and aggregate GDP or price dynamics. Moreover, whether the bank approves a loan request is contingent heavily on the bank's risk perception and risk tolerance. The second group of determinants is the source of funds. This group covers the quantity and quality of funds, funding sources, and the cost of funds. If the bank can raise a large amount of funding at a low cost, they would have more incentive to grant credits. The third group of determinants relates to competition in credit markets. This group encompasses the competition from banks and non-bank financial institutions.

We attempt to quantify roughly the relevance of each group of determinants in explaining the variation in corporate credit supply. We regress the actual credit standard ($SUPPLYSURVEY$) on the following potential determinants. First, the determinants relating to a bank's external cost of funds include bank capital ($CAPITAL$), funding market access ($MARKET\_ACCESS$), liquidity position ($LIQUIDITY$). Second, a bank's competition with other lenders includes competition against the other banks ($OTHER\_BANKS$), the equity market ($EQUITY\_MARKET$), the bond market ($BOND\_MARKET$), and foreign borrowing ($FOREIGN\_BORROWING$). The third group of determinants relates to banks' risk perception, it includes the general conditions of the economy ($GENERAL\_ECONOMY$), industry-specific conditions ($INDUSTRY\_SPECIFIC$), and collateral position ($COLLATERAL$). We resort to the Senior Loan Officer Survey on the determinants of credit standard. We estimate several specifications with the ordinary least square method and capture the R-squared statistics to measure each determinant's contribution to the total variation of credit standard, using the sample period from the fourth quarter of

2007 to the third quarter of 2020. Due to the lack of SME's data, we use the data of large enterprises.

Table 2 documents the estimation results. The determinants related to a bank's risk perception are the most influential determinants over the sample period. Specification 13 suggests that they jointly explain over 51.21% of the total variation in the Thai corporate credit standards, while Specification 10-12 also suggest that separate effects of each determinant are also significantly relevant. These findings indicate that the Thai bank's corporate credit approval process is significantly risk-based. That is, banks perceive and consider heavily various risks of lending before they grant credits. This conclusion helps explain why credit supply is constrained over the past decade, especially credit to SMEs since the Thai economy has been relatively vulnerable and volatile while inequality has increased. Meanwhile, the determinants related to funding and competition are relatively less influential. We note that the residual variance is considerable, accounting for over 39.48% of the total variation. It is more or less attributable to the other determinants we cannot measure, such as the perception of individual credit risk. Given that the residual variance is large, we suspect that the perception of individual risk is strongly relevant.

Table 2 Regression results of the determinants of Thai corporate credit standards

Dependent Variable : SUPPLYSURVEY	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CAPITAL	0.3870			0.0625			
	(0.2668)			(0.4171)			
MARKET_ACCESS		0.4496		0.8749*			
		(0.2793)		(0.4967)			
LIQUIDITY			-0.5018	-0.7916			
			(0.4291)	(0.4769)			
OTHER_BANKS					0.1579		
					(0.1469)		
EQUITY_MARKET						0.9093	
						(0.7352)	
BOND_MARKET							0.2865
							(0.3625)
FOREIGN_BORROWING							
GENERAL_ECONOMY							
INDUSTRY_SPECIFIC							
COLLATERAL							
constant	-6.702***	-6.755***	-7.602***	-5.224***	-9.767***	-8.753***	-8.872***
	(1.6639)	(1.4927)	(1.4233)	(1.4725)	(2.8313)	(1.9170)	(2.4940)
N	52	52	52	52	52	52	52
R-squared	0.0374	0.0422	0.0955	0.2389	0.0264	0.0860	0.0197
Adjusted R-squared	0.0181	0.0231	0.0774	0.1913	0.0070	0.0677	0.0001

Notes: The column number indicates specification number. Robust standard errors are Win parenthesis. *,**,*** indicate that the coefficient is significantly different from zero at 10%, 5%, and 1% significance level.
Source: Authors' Calculations

Table 2 Regression results of the determinants of Thai corporate credit standards (continued)

Dependent Variable : SUPPLYSURVEY	(8)	(9)	(10)	(11)	(12)	(13)	(14)
CAPITAL							0.0078
							(0.2423)
MARKET_ACCESS							0.1487
							(0.2679)
LIQUIDITY							-0.2250
							(0.2760)
OTHER_BANKS		0.0714					-0.0848
		(0.1354)					(0.1509)
EQUITY_MARKET		0.7769					0.2842
		(0.5505)					(0.3524)
BOND_MARKET		-0.2673					0.0868
		(0.2292)					(0.3292)
FOREIGN_BORROWING	2.0192	1.7841					1.2551
	(1.8320)	(1.6694)					(0.7677)
GENERAL_ECONOMY			0.4647***			0.4753***	0.3158
			(0.1218)			(0.1650)	(0.1960)
INDUSTRY_SPECIFIC				0.4522***		-0.0030	0.1290
				(0.1316)		(0.1749)	(0.2400)
COLLATERAL					0.6060**	-0.0224	-0.0725
					(0.2857)	(0.1771)	(0.1974)
constant	-7.632***	-8.350***	1.6462	2.3498	-4.179***	1.6596	2.1039
	(1.3744)	(2.2286)	(2.0946)	(2.5174)	(1.3052)	(2.2758)	(2.9426)
N	52	52	52	52	52	52	52
R-squared	0.1279	0.1801	0.5119	0.4520	0.2294	0.5121	0.6052
Adjusted R-squared	0.1105	0.1103	0.5022	0.4411	0.2139	0.4816	0.5089

Notes: The column number indicates specification number. Robust standard errors are Win parenthesis. *,**,*** indicate that the coefficient is significantly different from zero at 10%, 5%, and 1% significance level.
Source: Authors' Calculations

3. Synergy Between Credit Inclusion and Credit Risk: More Inclusive Today for Future Stability

Thus far, we have examined the corporate credit market distortion and constrained supply closely. The previous section sheds lights on two compelling findings. First, the corporate credit constraint is supply-driven. Second, Thai banks rely heavily on the risk-based approach to assess credit request. *Is risk-based credit assessment somehow attributed to constrained corporate credit supply? If so, then how?*

There has been a long debate among economists and policymakers about the relationship between credit inclusiveness and credit risks. *The key question is whether there is a trade-off between credit inclusiveness and risks.* Since the GFC, in which the unprecedented credit expansion led to economic recession, central banks have put a strong emphasis on financial stability. However, recent literature found that an overemphasis on financial stability may cause or exacerbate financial exclusion. Claessens (2006) argues that a regulatory framework that excessively focuses on financial stability may end up over-regulating fundamental financial services, which unintentionally excludes small firms from the financial system.

Many recent works of literature argued for the synergy between credit inclusiveness and credit risks. Hannig and Jansen (2010) explained that one should consider the trade-off between credit inclusiveness and credit risk, if it exists, in the longer term. Credit to SMEs is riskier than credit to large enterprise only in the early stage. With a proper credit approval process and credit contract designs, SME businesses should thrive and return sustainable profits. In fact, Mehrotra and Yetman (2014) argue that greater inclusion to credit markets equip broader ranges of firms with better tools for economic and financial risk management, making them more resilient to

shock. As clients become healthier, the banking sector also becomes healthier and more resilient to shocks. Furthermore, new proliferating businesses will add to thicker and well-distributed goods and labor markets which, in turn, contribute to the deeper and more diversified financial markets.

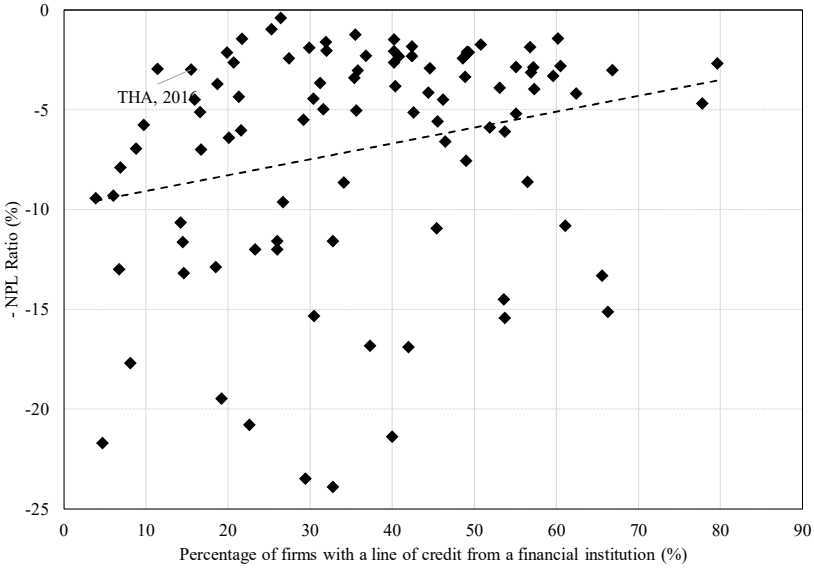
Cross-country evidence also supports the synergy between credit inclusiveness and risks. Morgan and Pontines (2014) use the cross-country panel data between 2005-11 to estimate the relationship between SME credit inclusiveness and the banking system's nonperforming loans (NPL). The result suggested that promoting SME credits significantly reduces NPLs. Morgan and Pontines also explain that the diversification towards SMEs credit helps lessen systemic risk due to the concentrated credit portfolio of large enterprises.

To better illustrate the credit inclusiveness - credit risk synergy, Figure 8 plots credit inclusiveness against credit risk. We measure credit inclusiveness by the percentage of firms in the formal sector with a line of credit or a loan from a financial institution. We measure risk by minus non-performing loans to gross loans ratio. We resort to the latest survey data from World Bank's Global Financial Development Database, which we focus on the records after the GFC ended.

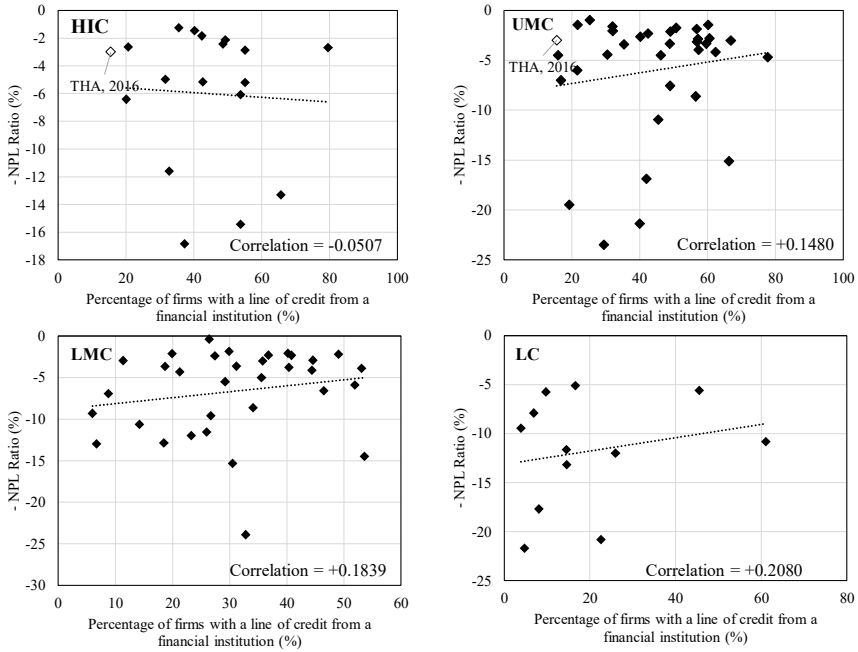
From Figure 8, we document the slightly positive relationship between credit inclusiveness and credit risk, the evidence in favor of synergies. The correlation between credit inclusiveness and credit risk is slightly positive. More interestingly, we find that synergies become more evident in less developed countries. On the other hand, there exists a negative but insignificant correlation between credit inclusiveness and credit risk among high-income countries.

Figure 8. Relationship between credit inclusiveness and credit risk

(a) Relationship between credit inclusiveness and credit risk



(b) Relationship between credit inclusiveness and credit risk by income groups



Note: Credit inclusiveness is measured by the percentage of firms in the formal sector with a line of credit or a loan from a financial institution. Credit risk is measured by minus non-performing loans to gross loans ratio. The data is the most recent values over the period 2009–2017. THA, HIC, UMC, LMC, and LIC refer to Thailand, the average of high-income countries, upper-middle-income countries, lower-middle-income countries, and low-income countries respectively.
Source: Global Financial Development Database, World Bank

Why? We conjecture that high-income countries have already developed inclusive and well functioned financial systems. So, the regulators can shift priority from promoting credit inclusiveness to managing credit risk. Furthermore, since the well-developed financial system is efficient and complicated, it enables new advanced financial innovations which are accompanied by more complex and unprecedented risk. Thus, the system warrants considerable attention to risk management. On the other hand, less developed countries with lower inclusiveness and less developed financial systems should put more emphasis on credit inclusion. The positive relationship between credit inclusiveness and credit risk not only allows developing economies to promote credit inclusion with less financial stability concerns than developed countries, but also encourages these economies to move to the more efficient allocation of risk and return on the upper-left region of the figure.

For the Thai economy, the Thai banking system has upheld its financial stability mandate very well. However, it significantly lacks credit inclusiveness compared to other upper-middle-income peers. These findings warrant the Thai banking system and the regulators to revisit the policy paradigm and regulatory framework with respect to credit inclusion and credit risk.

4. Policy Recommendation from Institutional Economics Perspective

In the previous section, we present the opportunity in which the Thai banking system could offer better credit inclusion, especially corporate credits, to achieve the more desirable allocation between credit inclusiveness and credit risk. *But how could the Thai economy achieve such*

allocation? In this last section, we attempt to provide a general solution from institutional economics perspectives.

From the view of institutional economics, incentives and institutional conditions that govern the behaviour of banks, as well as the regulator, play the key role in promoting greater corporate credit provision to small firms. Economic history advocates the importance of institutions in shaping the destiny of the banking system.

Here, we provide the renowned example of the French banking system. The French banking system is one of the most developed, sustainable, and inclusive banking systems in the world. BIS data indicates that the French economy in 2019 accumulated over 150.1% of corporate credit to GDP, ranking sixth out of 48 countries in the sample. The French banking system has also strongly supported SMEs. The European Banking Federation (EBF) data shows that new loans to SMEs accounted for 42% of total new loans granted in December 2019, with a 97% investment loan approval rate in the fourth quarter of 2019.

Interestingly, before this prominent success, the French economy had experienced days when the banking system was fragile, inefficient, and exclusive. We refer to Bertrand, Schoar, and Thesmar (2007) who studied the effects of the deregulation of the French banking industry in the 1980s on French banks' behaviour and the implications on the Schumpeterian process.

After the second world war ended in the 1940s, the French Government centralized the banking system under the Treasury's supervision. The government heavily intervened in banks' behaviours in two aspects. First, the Ministry of Finance established the Deposit Network, a network of influential banks and cooperatives. The Ministry of Finance subsidized Deposit Network's members with low-cost deposits and had assigned members to grant subsidized loans to some poorly

performing firms. Zombie lending accumulated as a result. Second, the major oil price shock in the 1970s precipitated a sudden increase in inflation and crippled economic growth, leading to severe stagflation, which posed a colossal policy dilemma. The French government provided subsidized loans via the Deposit Network's members to stimulate growth. To grapple with inflation, however, the French government refused to raise the interest rate. Instead, the Ministry of Finance curbed credit supply by issuing the so-called *Encadrement du crédit program*, which set the credit ceiling for the outsiders of the Deposit Network.

The intervention heavily distorted the banking market structure and impaired market mechanisms. Consequently, the banking system failed to reallocate financial resources efficiently. Eventually, the banking system distortion adversely affected the real economy. The French economy experienced a Balance of Payments deficit. Furthermore, the excessive intervention incurred high costs, causing government debt to hover.

As economic and political pressure increased, the government finally decided to implement banking reform in late 1984. The critical development is the enactment of the 1985 Banking Act, which literature attributes to be a major turning point of the French banking system's outlook. Under the 1985 Banking Act, the Treasury removed subsidized funds to Deposit Network's members and discarded the credit ceiling under *the Encadrement du crédit program*. The government also privatized big banks and cooperatives. This development has significantly changed the market structure of the French banking system as these financial institutions accounted for up to 20% of the total assets of the whole banking system at that time.

The enactment of the 1985 Banking Act has considerably improved the efficiency of financial resource allocation. The

French financial institutions cut zombie lending and started to allocate credit considering the actual return and risks. Furthermore, the new 1985 Banking Act helped bring down the dominance of Deposit Network's members and intensify competition within the banking system.

What can we learn from the French banking reform? First, excessive protection and interference from the government and the regulators could end up impairing the functionality of the banking system. The consequences are far-reaching as a dysfunctional banking system destabilized the French economy in the 1970s. Second, fair competition and equal distribution of financial resources and market power among banks are crucial to ensure the most efficient allocation of financial resources and the finest outcome for the economy as a whole.

5. Conclusion

Well-functioning banking systems are necessary but not sufficient to ensure that financial systems provide enough support to the real economy and to enable the equal distribution of economic opportunities. But the banking system needs appropriate institutional setup to induce better individual decision and to lubricate market mechanisms which finally returns the efficient and equal allocation of financial resources.

In this review paper, we illustrate that the Thai banking system could provide finer support to the real economy through greater and better corporate credit provision for investment purposes, especially to SMEs. We propose that the Thai banking system and the regulator should and could put more emphasis on credit inclusion. Credit risk management is crucial, but putting too much aversion to risk could result in undesirable outcomes. Lastly, the institutional setup is the key

to reset the course of the Thai banking system. Regulators cannot overprotect or intervene in the market mechanism. Instead, regulators should establish rules for fairer competition and equal allocation of market powers among banks.

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Technical Efficiency of Private Clinics Under Universal Coverage Scheme in Bangkok, Thailand

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ABSTRACT

This study aims to measure the technical efficiency of 88 private clinics under Universal Coverage Scheme (UCS) in Bangkok for the fiscal year 2017 and to identify the factors affecting their technical efficiency. This cross-sectional study uses secondary data collected in fiscal year 2017 (October 2016- November 2017), from the database of National Health Security Office (NHSO). The study is divided in to two parts. The first part measures technical efficiency with data envelopment analysis (DEA) and the second part identifies the factors affecting efficiency with regression analysis using a Tobit model.

The result of DEA under a variable return to scale assumption showed that 95.45 percent of the target study were operating on pure technical efficiency frontier (TEVRS), the mean pure technical efficiency score was equal to 0.98. Furthermore, the results of regression analysis revealed that only health supporting staff ratio was significantly affecting on pure technical efficiency (TEVRS) of private clinics under UCS.

Keywords: Technical efficiency, Data envelopment analysis, Private clinics

JEL classification: I180

1. Introduction

In Bangkok, Thailand private clinics have partnered with the Government to provide primary care service under UCS. Due to limited resources and lack of equity of access in health services, it is extremely challenging for private health agencies to manage their own available resources to achieve minimum cost and provide the best possible healthcare service at the same time. The term "efficiency" refers to the best use of resources in production. Data envelopment analysis (DEA) is one tool of measurement which focuses on technical efficiency which is producing the maximum amount of output from a given amount of input, or alternatively producing a given output with minimum quantities of inputs. Recently, it has been widely used in healthcare service studies. In Thailand, there are several previous studies about technical efficiency in hospitals and health centers under the Ministry of Public Health, but there is no study of private clinics under UCS.

This study aims to measure the technical efficiency of private clinics under UCS in Bangkok, Thailand for the fiscal year 2017 and to identify the factors affecting their level of technical efficiency. The result of this study is expected to provide mangers of private clinics participating in the UCS in Bangkok an understanding of their efficiency levels and to help them decide how to allocate their available resources to achieve greater efficiency.

2. Theoretical foundation of data envelopment analysis

The DEA is an efficiency measurement method proposed by Charnes, Cooper and Rhodes (1978) which is a non-parametric mathematical method for estimating production or cost frontier using linear programming to determine the efficiency index. This method can measure efficiency of units

which is called decision-making units (DMUs) that use multiple inputs and outputs. The inputs and outputs of each unit should be homogenous.

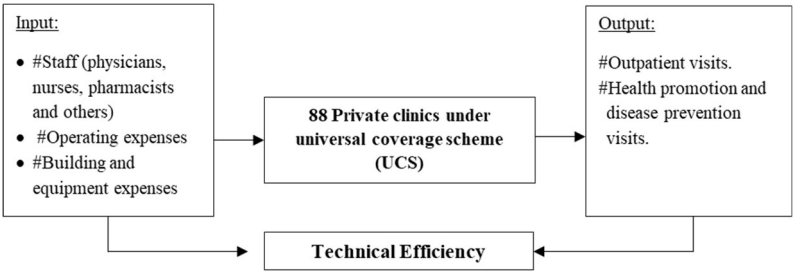
The efficiency index is calculated by measuring the ratio between weighted outputs and weighted inputs. Inputs and outputs should be weighted by assumed weight which is proper for linear programming. The DEA creates the efficiency frontier of DMUs, assuming that the value of DMUs which are on the efficient frontier is equal to 100% or 1, other DMUs which are below the frontier are less than 100% or 1 can calculated by the ration of distance of unit from its frontier. According to the concept, it is a relative efficiency measurement which compares between the DMUs; it may not be the best performance value.

There are 2 measurements: the first is the input-oriented measure explained by Farrell's (1957) conceptual framework, which considers the simple case of producing y using two inputs (x1, x2), assuming Constant Returns to Scale (CRS). The second measurement is an Output-oriented measurement, which aims to calculate the proportion of output that each DMU can produce with the same level of production. The advantages of this method are thatit can be used in mixed inputs and outputs without requiring weights. In addition, the analysis showed that poor performance values that is a guideline for development in term of increasing operational efficiency and reducing costs. In contrast, the disadvantages are the unit which in best practices may not be a real best performer because it cannot identify the relationship between outputs and inputs that indicates efficiency, and it cannot solve the problem of random error.

3. Concept and methodology for this study

This study is divided in to two parts. The first part measures the technical efficiency of private clinics under UCS with DEA using an input-orientated model. The inputs considered three variables: staff, operating expenses, and building and equipment expenses, while the outputs were the number of outpatient visits and the number of health promotion and disease prevention visits. The results of DEA show that the three associated efficiency scores consist of overall technical efficiency or technical efficiency under a constant return to scale assumption (TECRS) scores, pure technical efficiency or technical under a variable return to scale assumption (TEVRS) and scale efficiency (SE) scores. The DEA also shows the patterns of scale inefficiencies which are increasing return to scale (IRS) and decreasing return to scale (DRS). The concept can be seen in Figure 1.

Figure 1. Measuring technical efficiency with data envelopment analysis (DEA)



The second part identifies the factors affecting efficiency with regression analysis using Tobit model. The dependent variable was TEVRS which was the result of DEA analysis from the first part and the independent variables considered were seven expected factors based on previous studies and characteristics of private clinics under UCS. These

independent variables were defined as organizational characteristics and external environments. The organizational characteristics were ratio of staff and health service, the number of UCS members and type of clinics and the external environment as location. The identification of factors is shown in the following Figure 2 and the explanatory variables for Tobit regression analysis is showed in the following Table 1.

Figure 2. Identifying the factors affecting efficiency with regression analysis using Tobit model

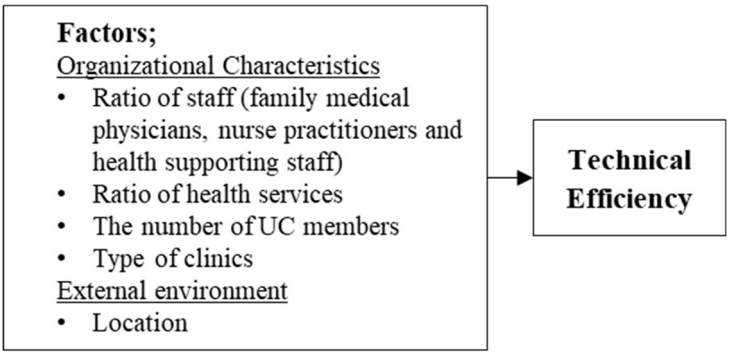


Table 1. Explanatory variables for Tobit regression analysis

Variables	Type	Sources	Description
Ratio of family medical physician	Quantitative	Public online data base (NHSO, 2018)	Ratio of family medical physician to other staff.
Ratio of nurse practitioner	Quantitative	Public online data base (NHSO, 2018)	Ratio of nurse practitioner to other staff.
Ratio of health supporting staff	Quantitative	Public online data base (NHSO, 2018)	Ratio of health supporting staff other staff.
Ratio of health promotion and disease	Quantitative	Non-public online data base (NHSO, 2018)	Ratio of health promotion and prevention visits to other visits.

Variables	Type	Sources	Description
prevention service			
The number of Universal Coverage (UC) member	Dummy	Non-public online data base (NHSO, 2018)	The number of Universal Coverage (UC) member; 1= it is under NHSO's condition 0= it is not under NHSO's condition
Type of clinics	Dummy	Public online data base (NHSO, 2018)	Type of clinics; 1= non-united clinic 0= united clinic
Location	Dummy	Public online data base (NHSO, 2018)	Location in Bangkok; 1=Outer area (urban fringe part and suburb part) 0=Inner area

Thus, the empirical regression model is:

$$\mathbf{TEVRS} = \beta_0 + \beta_1 \mathbf{RFM} + \beta_2 \mathbf{RPN} + \beta_3 \mathbf{RHS} + \beta_4 \mathbf{RPP} + \beta_5 \mathbf{UC} + \beta_6 \mathbf{TC} + \beta_7 \mathbf{LOC} + \varepsilon$$

Where:
TEVRS= Technical efficiency under a variable return to scale assumption
RFM = Ratio of family medical physician
RPN = Ratio of nurse practitioner
RHS = Ratio of health supporting staff
RPP = Ratio of health promotion and disease prevention service
UC = Number of Universal Coverage Scheme (UC) members
TC = Type of clinics
LOC= Outer area (urban fringe part and suburb part)
ε= Error term that captures other possible factors no specified

4. Results

4.1 Technical and scale efficiency scores

The DEA analysis with input-oriented assumption showed that the average technical efficiency score under a

constant return to scale assumption (TECRS) was equal to 0.82 (SD = 0.15). The pure technical efficiency score or technical efficiency score under a variable return to scale assumption (TEVRS) was equal to 0.98 (SD=0.03) and scale efficiency score (SE) was equal to 0.84 (SD=0.13). It can be observed that the result of TEVRS, the minimum number of efficient score was equal to 0.56 (the highest score=1) while TECRS was equal to 0.35 (the highest score=1).

Table 2. Descriptive statistics for TECRS, TEVRS and SE

TE	Mean	Median	Maximum	Minimum	S.D.
TECRS*	0.82	0.86	1.00	0.35	0.15
TEVRS**	0.98	1.00	1.00	0.56	0.03
SE***	0.84	0.87	1.00	0.35	0.13

***** Technical efficiency score under a constant return to scale assumption

****** Pure technical efficiency score or technical efficiency score under a variable return to scale assumption

******* Scale efficiency score

The TE scores from the input-oriented DEA model, from 88 private clinics, showed 84 private clinics were on technical efficiency under a constant return to scale assumption (TECRS) frontier while others were inefficient; it was 95.45 percent of the total units. There were 23 private clinics which were pure technical efficient or technical efficienct under a variable return to scale assumption (TEVRS) and scale efficiency frontier; it was 26.14 percent of the total units. It can be seen that the private clinics under UC can manage the healthcare service efficiently.

Table 3. Descriptive statistics of TE scores from Input oriented DEA model

TE	Private clinics on frontier (units)	Percentage (Total =88 units)
TECRS*	23	26.14
TEVRS**	84	95.45
SE***	23	26.14

* Technical efficiency score under a constant return to scale assumption
** Pure technical efficiency score or technical efficiency score under a variable return to scale assumption
*** Scale efficiency score

The private clinics under UC which showed CRS was equal to 23 units and IRS (increasing return to scale) was equal to 64 units while DRS was equal to 1 unit. Therefore, the results proved that increasing return to scale was higher than decreasing return to scale. It means that the percentage increases in outputs was more than percentage change in all inputs.

Table 4. Descriptive statistics of the patterns of scale inefficiencies

	CRS*	DRS**	IRS***
Private Clinics under UCS	23	1	64

*Constant return to scale (CRS)
**Decreasing return to scale (DRS)
***Increasing return to scale (IRS)

4.2 The result of regression

The results revealed coefficient standard error, z-Statistic and probability of seven explanatory variables: family medical physician ratio, nurse practitioner ratio, health supporting staff ratio, health promotion and disease prevention service ratio,

the number of UCS members, type of clinics and location. The results showed that only health supporting staff ratio had a significant effect on TEVRS of private clinics under UCS where probability was less than 0.05 while other explanatory variables had an insignificant effect on TEVRS of private clinics under UCS where probability was higher than 0.05.

Table 5. Tobit Regression results

Variables	Coefficient	Std. Error	z-Statistic	Prob.
1. Family Medical Physician Ratio	-0.0908383	0.1409311	-0.6445582	0.5192136
2. Nurse Practitioner Ratio	-0.1084353	0.1755673	-0.6176282	0.5368205
3. Health Supporting Staff Ratio	0.0564399	0.0218972	2.5774926	0.009952
4. Health Promotion and Disease Prevention Service Ratio	-0.0565734	0.0340754	-1.6602421	0.0968657
5. The Number of Universal Coverage (UC) Members (dummy)	0.0191022	0.0158423	1.2057768	0.2279036
6. Type of Clinics (dummy)	0.0041576	0.0196654	0.2114179	0.8325612
7. Location (dummy)	0.005992	0.0189911	0.3155185	0.752368

Number of observations = 88, Confidence Interval 95%, RSS =0.405149

5. Conclusion and Policy Implications

This study aimed to apply an accuracte tool of efficiency measurement for indicating the level of technical efficiency score of private clinics under UCS in Bangkok, Thailand and to investigate the factors that determine their technical efficiency scores.

The first part measured technical efficiency of private clinics under UCS by DEA using an input-orientated model. The results showed that the private clinics under UCS manage

their resources to provide healthcare services efficiently. The average TEVRS was 0.98 and there were 84 private clinics under UCS, calculated as 95.45 percent of the total number of target study operating at TEVRS frontier. Most private clinics under UCS showed increasing return to scale, meaning that output increases by a larger proportion than the increase in inputs during the operating process, so this group should expand their scale of operation. Moreover, the ratio of outputs to population showed that there was opportunity to increase healthcare services to cover the entire population. Private clinics under UCS which showed increasing return to scale should increase their healthcare services. In contrast, some private clinics under UCS which showed decreasing return to scale (DRS), meaning that output increases by less than proportional change in inputs, should reduce their scale of operation appropriately.

The second part identified the factors affecting efficiency of private clinics UCS using Tobit regression analysis. The number of observations was equal to 88, confidence interval at 95 percent, the residual sum of squares was equal to 0.40. The results revealed that only the health supporting staff ratio significantly affected the TEVRS of private clinics under UCS. The coefficient was equal to 0.06. It was proved that the health supporting staff ratio had a positive relation with private clinics under UCS's TEVRS score. In contrast, other explanatory variables such as family medical physician ratio, nurse practitioner ratio, health promotion and disease prevention service ratio, the number of UCS members, type of clinics and location had an insignificant effect on TEVRS of private clinics under UCS. It means these explanatory variables were not associated to increasing pure technical efficiency of private clinics under UCS.

According to the results, in order to achieve appropriate scale of operation, private clinics under UCS which showed

IRS should expand their scale of operation while some private clinics under UCS which showed DRS should reduce their scale of operation. Furthermore, increasing the health supporting staff ratio should be considered in private clinics under UCS in Bangkok. Private clinic mangers can use these as evidence base for allocating healthcare resources efficiently and designing operations suitable for private clinics under UCS in Bangkok.

6. Limitations

This study aimed to measure technical efficiency of private clinics which were registered in the UCS system in Bangkok in the fiscal year 2017. The total number of clinics was 165, but some data were not complete, especially the data of on the number of staff which need to be used for DEA analysis, so some private clinics were eliminated from this study.

Some data regarding input variables are assumed for calculation because the data were not available such as number of staff, salary of personnel, operating expenses and building and equipment expenses.

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How Subjective Well-Being and Physical Health Are Linked: Mediation Analysis

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ABSTRACT

In this paper, the authors study the direct and indirect effects of subjective well-being on physical health using mediation analysis. Subjective well-being is captured by two separate measures: one for overall life satisfaction and one for mental health. Using thirteen waves (2005-2017) of the data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey, the authors consider physical activity, social interaction, smoking, drinking alcohol, outdoor tasks and volunteer or charity work as potential mediators. The authors find that the direct and indirect effects of past overall life satisfaction and past mental health are positively influenced present physical health. The indirect effects of this influence stand at 9.53% and 9.78% of the total effect of past overall life satisfaction and the total effect of past mental health, respectively, on physical health. Specifically, physical activity is a strong mediator in determining present physical health. As a result, for promoting better health, the design of health policies should consider both the direct and indirect effects of overall life satisfaction (or mental health) on physical health.

Keywords: physical health, well-being, mediation analysis, panel data, HILDA

JEL Classification: D01, I10

1. Introduction

Across the literature, there is strong evidence of the link between subjective well-being and health (see Diener et al., 2017 for a meta-analytic review; Diener, Lucas, & Oishi, 2002; Sin, 2016 for other reviews). However, the focus has been mostly on the direct link between subjective well-being and health, while little is known about the potential pathways through which subjective well-being affects an individual's physical health (i.e., the so-called "mediation effect"). Understanding such pathways and how heterogeneous they are between population groups could have important health policy implications. To fill this gap, this paper proposes a mediation framework and employs the multiple mediation analysis to examine factors that could potentially mediate the relationship between subjective well-being and physical health.

In order to shed some light on the mediators of this relationship, it is reasonable to consider the conceptual framework of how subjective well-being influences physical health. For example, Ong (2010) reviewed many studies on how well-being may influence an individual's health through several pathways, such as physiological systems (e.g., cardiovascular and immune systems), stress, and health behaviours (e.g., physical activity, diet, smoking). People with higher-level well-being are more likely to exercise more regularly, smoke less and consume a healthier diet (Boehm, Vie, & Kubzansky, 2012; Contoyannis & Jones, 2004). In light of these findings, this paper focuses on the mediation role of two forms of human capital investments, namely lifestyle choices (such as physical activity, smoking, drinking alcohol and outdoor tasks) and social capital (social interaction and volunteer or charity work).

To the best of our knowledge, the only study on health that employs mediation analysis is Ohrnberger et al. (2017),

who investigated the direct and indirect relationships between physical health and mental health. They analysed the direct and indirect effects of past mental health on physical health and vice versa. Focusing on a population of people aged 50 years and older, they used physical activity, social interaction and cigarette consumption as mediators in the indirect effect model. Using a random-effects model, they found that the effect of past mental health on current physical health is mediated by physical activity and social interaction. However, they ignored some important mediators proposed by previous studies (e.g., Mujcic & Oswald, 2016; Stampfer et al., 2005), such as dietary choices, drinking alcohol and other lifestyle choices.

Our paper expands this analysis by covering a wider age-range population and by including more mediators, such as frequency of alcohol consumption, spending time on outdoor tasks and participating in volunteer or charity work. Furthermore, in this study, the authors also improved the estimation by including the individual-specific means of time-varying variables as additional regressors in the estimation of the random effects to proxy the fixed-effect (Mundlak, 1978). Using data from the Household Income and Labour Dynamics of Australia (HILDA) survey, the findings reveal that the direct and indirect effects of past overall life satisfaction and past mental health are significantly related to present physical health. The indirect effect of past overall life satisfaction and past mental health on present physical health is strongly mediated by past physical activity. Furthermore, these findings are consistent when the heterogeneity by gender is taken into account. The findings are robust under alternative specifications and limitations of the data.

2. Conceptual and mediation framework

Grossman's model (Grossman, 1972) presents health as a part of human capital because healthy time provides individuals with production benefit as an input to the production of income. As a part of human capital, an individual's health can be increased through investments (i.e., people can adopt healthy behaviours such as socialising, taking part in physical activities, eating a healthy diet, and avoiding smoking and alcohol consumption to increase their stock of health capital).

The authors adopt this framework to identify several potential factors mediating the relationships between subjective well-being and physical health. The mediator variables are expected to affect physical health and be affected by subjective well-being. Therefore, the authors first identify the factors that determine physical health.

Many psychological, epidemiological, and economic studies consider socioeconomic factors, lifestyle choices, and individual characteristics as determinants of health (World Health Organization, 2017; Kelly, 2009). Socioeconomic factors, such as income and labour market status, are found to have positive correlations with health. For instance, individuals with higher incomes tend to be healthier than those with lower incomes (van Doorslaer and Koolman, 2004; Lenhart, 2017). Further, individuals with physically demanding occupations are likely to face health problems earlier in life than those in other occupations (Llena-Nozal et al., 2004).

With regard to lifestyle choices, there is a strand of research that investigates the impacts of health behaviours (such as physical activity, smoking, alcohol consumption, and dieting) and social interaction on physical and mental health. For example, Contoyannis and Jones (2004) found that

sufficient sleep, exercise, and not smoking positively contribute to people's health status. In addition, Durstine et al. (2013) reveal that physical health is positively correlated with physical activities: higher physical activity and exercise help reduce cardiovascular disease, type II diabetes, obesity, and cancer. Regarding social interaction, Steptoe et al. (2013) found that loneliness and social isolation significantly increase mortality risk while controlling for baseline mental health and physical health.

In light of these findings, it is clear that a study of the direct and indirect effects of subjective well-being on physical health is relevant, especially when using mediation analysis.

3. Data and variables

In this paper, the authors utilised data from the Household, Income, and Labour Dynamics of Australia (HILDA) Survey (2005-2017).[1] HILDA is an Australian national representative household-based longitudinal survey, which collects data on economic, labour market dynamics, subjective well-being, and family life. The survey started in 2001, and data are obtained from almost 14,000 individuals from 7,682 households who are at the age of 15 and above.

Based on the HILDA survey, the analytical sample for the present study consisted of respondents aged between 15 and 85 over the sample period.[2] After excluding observations with

[1] The authors are not able to utilise data from waves 1-4 as one of the explanatory variables on private health insurance is available only from wave 5 onwards.

[2] Understanding mortality selection at old age, for example, the individuals who are still alive at very old age could have low levels of physical health or mental health than their younger counterparts. The older people may also face higher mortality rate. To mitigate this concern, the authors deselected individuals aged 85 and higher in this analysis.

missing answers, the final sample was 14,055 individuals (6,304 males, 7,751 females) and 65,937 observations (28,288 males, 37,649 females).

3.1 Physical health measure

Physical health is obtained from the 36-item Short Form Survey (SF-36), which is based on the answers to 21 questions designed to capture four dimensions of an individual's physical health.[3] Table 1 shows the summary of physical health, including how physical health is defined in each dimension.

Table 1. SF-36: Physical Health

Summary	Scales	Meaning
Physical health	Physical Functioning (PF: 10 items)	Limitation of daily physical activities such as walking 100 meters.
	Role Physical (RP: 4 items)	Limitation of work caused by physical health such as difficulty performing the work
	Bodily Pain (BP: 2 items)	Pain and limitation of pain.
	General Health (GH: 5 items)	Health status.

In this paper, the authors also provided the test result of Cronbach's alpha for the four dimensions of physical health. The Cronbach's alpha test scale is slightly above 0.85, indicating that the different dimensions of physical health are sufficiently and closely related to one another. This enables us to construct a single index for physical health by computing the average of the four physical health dimensions for each

[3] Besides, one question covers a change in health status over the past year. This was not taken into account while scoring the four dimensions of physical health but was used to estimate the change in health from a cross-sectional administration of the SF-36.

observation (e.g., Hemingway et al., 1997; Zhu, 2016; Kesavayuth et al., 2020). Then, the authors obtained physical health measures ranging from 0 to 100, where the higher scores indicate better physical health and the lower scores indicate negative physical health. Finally, to aid the interpretation of the results, the authors divided the physical health scores by 10 so that the scale ranges from 0 to 10.

3.2 Subjective well-being variables

According to Diener (1984), subjective well-being (also called "self-reported wellbeing") refers to how people experience the quality of their lives and includes having good mental or physical health, a sense of meaning or purpose or fulfilment, and the ability to manage stress. For example, people who experience good feelings such as joy, hope, and positive thinking are more likely to enjoy a high quality of life (Skevington & Böhnke, 2018). Furthermore, other dimensions of one's well-being (such as life satisfaction, not just negative emotions such as stress and depression) can potentially influence healthier behaviors (Grant et al., 2009). Definitions of subjective well-being therefore focus on how people evaluate his/her own life, including emotions and moods (Diener, 2000). The findings of studies that focus on these variables can help policymakers in offering support for programs aimed at increasing societal welfare and contribute to a better quality of life for citizens and communities across the world (OECD Better Life, 2013; Stiglitz et al., 2010). However, our subjective well-being is captured by two separate measures: one for overall life satisfaction and one for mental health. Indeed, we believe that people who are highly satisfied with their life and have good mental health are deemed to have high levels of subjective well-being (i.e., they

are generally happy people), would be in better physical health simply.

Overall, life satisfaction is often measured as part of well-being. For example, the question on overall life satisfaction asks, "All things considered, how satisfied are you with your life?" The answers are reported on a scale ranging from 0 (totally dissatisfied) to 10 (totally satisfied). The overall life satisfaction measure has been widely used in the literature since it has been shown that there is little difference in estimating effects using a cardinal or ordinal model (Ferrer-i-Carbonell and Frijters, 2004). However, in this paper, the overall life satisfaction measure was treated as cardinal.

The second measure of well-being is mental health. Note that the authors measured mental health using the five-item Mental Health Inventory (MHI-5), which is a part of the SF-36. The MHI-5 has proven to be a good psychometric method, with a high Cronbach's alpha of 0.82 (Butterworth and Crosier, 2004). It has been extensively employed in the literature and has consistently shown to be as good as a proxy for a person's mental health. (e.g., Roy & Schurer, 2013; Berwick et al., 1991). For example, individuals were asked how often, over the past 4 weeks, they have felt (i) nervous person, (ii) calm and peaceful, (iii) down, (iv) happy, and (v) so down in the dumps that nothing could cheer you up. These five questions are then added together to create an index that is reported on a scale from 0 (all of the time) to 6 (none of the time). In the HILDA survey, a standardised self-reported measure of this mental health score ranged from 0 to 100 scales, where the higher scores indicate better mental health and the lower scores indicate worse mental health. Then to aid the interpretation of the results, the authors divided the mental health scores by 10 so that the scale ranges from 0 to 10.

3.3 Mediator variables

In this paper, multiple mediation analyses were performed to assess the relationship between overall life satisfaction (or mental health) and physical health through the mediator's lifestyle choices (such as frequency of physical activity, frequency of smoking, frequency of drinking alcohol and hours spent on outdoor tasks) and mediator's social capital (frequency of social interaction and hours spent on volunteer or charity work).

The authors considered six mediator variables as the main mediating factors for the following reasons. Firstly, these mediators are important predictors of mortality. For example, physical activity, smoking, and drinking alcohol are major risk factors for heart diseases, cancers and musculoskeletal disorders (Australia's Mental and Physical Health Tracker, 2018), which lead to higher risks of mortality. Social interaction is similarly important in increasing the risks of mortality: people who are socially isolated are often associated with higher mortality, especially in older men and women (Steptoe et al., 2013).

Secondly, mediator variables can be chosen by performing a literature review to determine conceptual theory (i.e., the relationship between mediator variables and dependent variable) and action theory (i.e., the relationship between the independent variables of interest and mediator variables) (Chen, 1990). Based on prior research, people with physical activity (i.e., those who exercise regularly) are likely to have improved physical health. That is, they are less likely to suffer from diseases such as cardiovascular disease, diabetes, obesity, and cancer (Durstine et al., 2013). Evidence from Durstine et al. (2013) indicates that physical health positively correlates with physical activity. Other potential mediators such as smoking and drinking alcohol are also

related to mental health; for example, people with mental health problems may be more likely to smoke or drink so as to regulate the symptoms or emotions associated with their condition (Cornah, 2006; Minichino et al., 2013). In addition, there is currently insufficient evidence showing that outdoor tasks and volunteer or charity work can explain high levels of physical health. Nevertheless, there is evidence that time spent on outdoor tasks and volunteer or charity work may also have effects on health (Kesavayuth et al., 2020). Finally, information on all mediators is available in the HILDA survey.

3.4 Control variables

A number of socioeconomic variables are included in the model, namely age, gender, household size, real household income in thousands of AUD,[4] the number of children living in the household, educational attainment, private health insurance, living as a couple, employment status, Australian states of residence and territories, and survey waves. The summary statistics of these variables are provided in Table 2, which also describes all these variables.

[4] The base year is 2012.

Table 2. Descriptive Statistics

Variables	Description	Mean	SD
Physical health (SF-36)	0-10 scale; with 0 = worst physical health and 10 = best physical health	7.49	2.20
Lagged overall life satisfaction	0-10 scale; with 0 = totally dissatisfied with life and 10 = totally satisfied with life	7.92	1.38
Lagged mental health (MHI-5)	0-10 scale; with 0 = worst mental health and 100 = best mental health and 10 = best mental health	7.53	1.67
Lagged frequency of physical activity	0-5 scale; with 0 = not at all and 5 = every day	2.57	1.51
Lagged frequency of social interaction	0-6 scale; with 0 = less often than once every 3 months and 6 = every day	3.46	1.43
Lagged frequency of smoking	0-3 scale; with 0 = non-smokers and 3 = smoke daily	0.47	1.06
Lagged frequency of drinking	0-6 scale; with 0 = no drinking and 6 = drink every day	2.51	1.83
Lagged outdoor tasks	Number of hours per week spent in outdoor tasks	4.31	6.01
Lagged volunteer or charity work	Number of hours per week spent in volunteer or charity work	1.18	3.35
Age	Age of the respondent	49.58	16.37
Male	1 if male, 0 if female	0.43	0.49
Household size	Number of persons living in the household	2.59	1.35
Real household income	Real household income in thousands of AUD (base year, 2012)	83.02	59.83
Number of children in the household	Number of children living in the household.	0.76	1.09
Private health insurance	1 if the respondent spent annual household expenditures on private health insurance, 0 otherwise	0.59	0.49
Living as a couple	1 if legally married and de facto, 0 otherwise	0.70	0.46
High education	1 if graduated at least from college, 0 otherwise	0.62	0.48
Employed	1 if employment, 0 otherwise	0.64	0.48
Unemployed	1 if unemployed, 0 otherwise	0.02	0.14
Not in the labour force	1 if not in the labour force, 0 otherwise	0.34	0.47

Notes: Number of observations 65,937.

4. Empirical approach

This study investigated the relationship between subjective well-being and physical health with mediation using Baron and Kenny (1986), which has been widely utilized

in psychological and economic studies. However, instead of looking at only one mediator, this study considered multiple mediators that cover human capital investment: social capital and lifestyle choice.

The authors started by using conventional panel methods (i.e., random effect and fixed-effect panel regression) to estimate the model. In the random effect model, the unobservable variables were assumed to be uncorrelated with the observed variable. On the other hand, unobserved variables were allowed to have correlations with the observed variables in the fixed-effect model. Then, the authors considered an alternative specification that directly controls for individual specifics. This was controlled for in the remaining correlation between individual specifics and the regressors. That alternative specification was proposed by Mundlak (1978), who argued that it is a more parsimonious and flexible method.[5] The authors estimated random effect by including the individual-specific means of the time-varying variable as additional control variables in order to proxy the fixed-effect outcome. This minimises the potential for time-invariant unobserved heterogeneity to bias the estimates. Hence, the estimation equation is given by:

$$PH_{it} = b_0 + b_1 SWB_{i,t-1} + b_2 PA_{i,t-1} + b_3 SI_{i,t-1} + b_4 S_{i,t-1} + b_5 D_{i,t-1} + b_6 OT_{i,t-1} + b_7 V_{i,t-1} + b_8 X_{it} + b_9 \overline{X}'_{it} + v_{it} \quad (1)$$

where PH_{it} is the physical health of individual *i* at time *t*, $SWB_{i,t-1}$ refers to subjective well-being (overall life

[5] Mundlak (1978) proposed that individual effects are a linear function of the means of all the time-varying variables across time. This method allowed us to obtain the equivalent of fixed effects.

satisfaction or mental health) at *t*-1, $PA_{i,t-1}$ is the frequency of physical activity at *t*-1, $SI_{i,t-1}$ is the frequency of social interaction at *t*-1, $S_{i,t-1}$ is the frequency of smoking at *t*-1, $D_{i,t-1}$ is the frequency of drinking alcohol at *t*-1, $OT_{i,t-1}$ is the number of hours spent on outdoor tasks at *t*-1, $V_{i,t-1}$ is hours spent on volunteer or charity work, X_{it} is a vector of predictor variables, and $\overline{X}'_{it}$ *i*s a vector of means of predictor variables that vary over time, including age, household size, real household income, the number of children living in the household, educational attainment, private health insurance, living as a couple, employment status, Australian state of residence and territories. Finally, v_{it} is a composite error term that consists of a person-specific error μ_i and an idiosyncratic error ε_{it}.

In equation (1), the direct effect of past subjective well-being (past overall life satisfaction or past mental health) on present physical health was measured by the coefficient b_1.[6] In order to estimate the indirect effect, the authors evaluated how past subjective well-being could influence the mediators. Hence, the authors considered six additional equations:

$$PA_{it-1} = a_{01} + a_{11}SWB_{i,t-1} + a_{21}X_{i,t-1} + a_{31}\overline{X}'_{i,t-1} + e_{i,t-1} \quad (2)$$

$$SI_{it-} = a_{02} + a_{12}SWB_{i,t-1} + a_{22}X_{i,t-1} + a_{32}\overline{X}'_{i,t-1} + e_{i,t-1} \quad (3)$$

[6] The authors thus estimated equation (1) two times to obtain the coefficients of past overall life satisfaction and past mental health.

$$S_{it-1} = a_{03} + a_{13}SWB_{i,t-1} + a_{23}X_{i,t-1} + a_{33}\overline{X}'_{i,t-1} + e_{i,t-1} \quad (4)$$

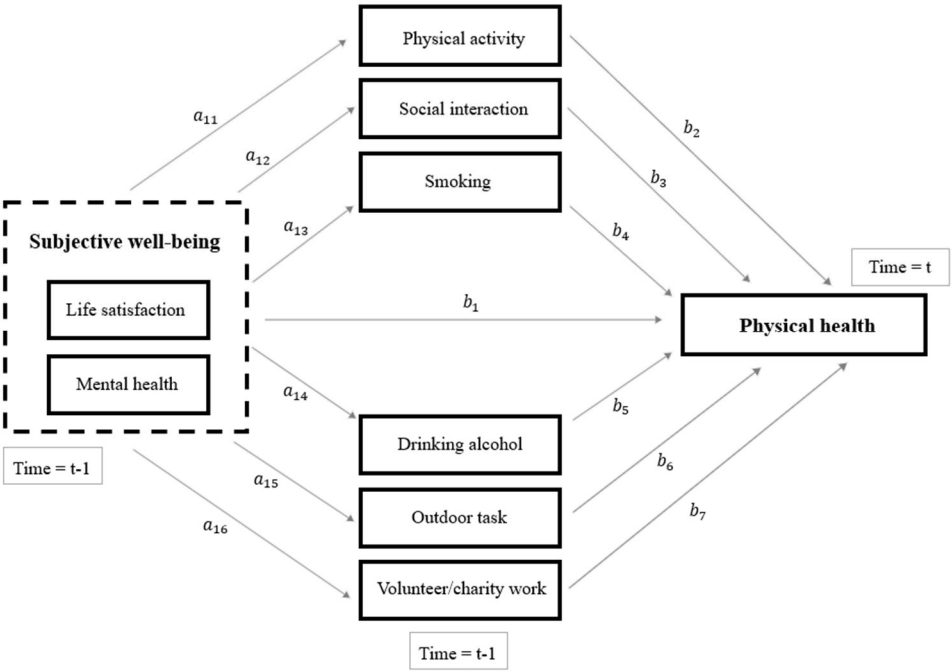
$$D_{it-1} = a_{04} + a_{14}SWB_{i,t-1} + a_{24}X_{i,t-1} + a_{34}\overline{X}'_{i,t-1} + e_{i,t-1} \quad (5)$$

$$OT_{it-1} = a_{05} + a_{15}SWB_{i,t-1} + a_{25}X_{i,t-1} + a_{35}\overline{X}'_{i,t-1} + e_{i,t-1} \quad (6)$$

$$V_{it-1} = a_{06} + a_{16}SWB_{i,t-1} + a_{26}X_{i,t-1} + a_{36}\overline{X}'_{i,t-1} + e_{i,t-1} \quad (7)$$

To calculate the indirect effect, it is defined as the multiplication of the path coefficient $a_{1j}b_k$ (j=1 to 6; k= 2 to 7). For example, the indirect effect of past overall life satisfaction (or past mental health) on present physical health by past physical activity is $a_{11}b_2$. Similarly, the total indirect effect of past overall life satisfaction (or past mental health) on present physical health by six mediators is the summation of all indirect effects: $a_{11}b_2 + a_{12}b_3 + a_{13}b_4 + a_{14}b_5 + a_{15}b_6 + a_{16}b_7$. The effect of past subjective well-being on each mediator variable is shown in Figure 1.

Figure 1. The direct and indirect effects of subjective well-being on physical health via multiple mediators.



4.1 Testing the indirect effect

According to MacKinnon et al. (2002), the mediation effect testing can be categorised into four types: the causal-steps test, product-of-coefficients test, difference-in-coefficients test, and the resampling method. In this paper, the product of the coefficients approach, which applies to models with multiple mediators (Baron and Kenny, 1986; Preacher and Hayes, 2008a), was applied.

The null hypothesis is to test if the indirect effect is significantly different from zero. The indirect effect is calculated from the product of (i) pathway a_{1j} (j=1 to 6),

which is the effects of past overall life satisfaction (or past mental health) on any mediator variables, and (ii) pathway b_k (k= 2 to 7), which is the effects of any mediator variables on physical health. To test the null hypothesis, the authors utilised the Sobel test (Sobel, 1982) for analysis.

The Sobel test considers the value of the standard error of pathway a_{1j} ($se_{a_{1j}}$) and pathway b_k (se_{b_k}). The indirect effect $a_{1j}b_k$ and its standard error $se_{a_{1j}b_k}$ were computed (Baron and Kenny, 1986; Goodman, 1960; MacKinnon, 2000; Preacher & Hayes, 2004; Sobel, 1982). Sobel's Z of indirect effect is given as:

$$Z_{a_{1j}b_k} = \frac{a_{1j}b_k}{\sqrt{{a_{1j}}^2 {se_{b_k}}^2 + {b_k}^2 {se_{a_{1j}}}^2}}; \quad j = 1, 2, \ldots, 6 \text{ and } k = 2, 3, \ldots, 7 \tag{8}$$

where $se_{a_{1j}}$ and se_{b_k} are the standard error of the coefficient a_{1j} and b_k respectively.

4.2 Testing the total indirect effect

The total indirect effect of past overall life satisfaction (or past mental health) on present physical health by six mediators is the summation of each indirect effect. The authors then used the Sobel test to test whether the total indirect effect is also statistically significant. Importantly, the standard error of the total indirect effect is corroborated by Preacher and Hayes (2008b). They show that the total indirect effect is the sum of each indirect effect: $f = a_{11}b_2 + a_{12}b_3 + a_{13}b_4 + a_{14}b_5 + a_{15}b_6 + a_{16}b_7$. Using methods from Bollen (1987), the asymptotic variance of a total indirect effect of past overall life satisfaction (or past mental health) is as follows

$$\mathrm{Var}(f) = b_2^2 se_{a_{11}}^2 + a_{11}^2 se_{b_2}^2 + b_3^2 se_{a_{12}}^2 + a_{12}^2 se_{b_3}^2 + b_4^2 se_{a_{13}}^2 + a_{13}^2 se_{b_4}^2 + b_5^2 se_{a_{14}}^2 + a_{14}^2 se_{b_5}^2 + b_6^2 se_{a_{15}}^2 + a_{15}^2 se_{b_6}^2 + b_7^2 se_{a_{16}}^2 + a_{16}^2 se_{b_7}^2 + 2(a_{11}a_{12} se_{b_2,b_3} + a_{11}a_{13} se_{b_2,b_4} + a_{11}a_{14} se_{b_2,b_5} + a_{11}a_{15} se_{b_2,b_6} + a_{11}a_{16} se_{b_2,b_7} + a_{12}a_{13} se_{b_3,b_4} + a_{12}a_{14} se_{b_3,b_5} + a_{12}a_{15} se_{b_3,b_6} + a_{12}a_{16} se_{b_3,b_7} + a_{13}a_{14} se_{b_4,b_5} + a_{13}a_{15} se_{b_4,b_6} + a_{13}a_{16} se_{b_4,b_7} + a_{14}a_{15} se_{b_5,b_6} + a_{14}a_{16} se_{b_5,b_7} + a_{15}a_{16} se_{b_6,b_7} + b_2b_3 se_{a_{11},a_{12}} + b_2b_4 se_{a_{11},a_{13}} + b_2b_5 se_{a_{11},a_{14}} + b_2b_6 se_{a_{11},a_{15}} + b_2b_7 se_{a_{11},a_{16}} + b_3b_4 se_{a_{12},a_{13}} + b_3b_5 se_{a_{12},a_{14}} + b_3b_6 se_{a_{12},a_{15}} + b_3b_7 se_{a_{12},a_{16}} + b_4b_5 se_{a_{13},a_{14}} + b_4b_6 se_{a_{13},a_{15}} + b_4b_7 se_{a_{13},a_{16}} + b_5b_6 se_{a_{14},a_{15}} + b_5b_7 se_{a_{14},a_{16}} + b_6b_7 se_{a_{15},a_{16}}) \quad (9)$$

Therefore, the Sobel test's Z of total indirect effect is given as:

$$Z_f = \frac{f}{\sqrt{\mathrm{Var}(f)}} = \frac{\sum a_{1j} b_k}{\sqrt{\mathrm{Var}(f)}}\ ;$$
$$j = 1, 2, \ldots, 6 \text{ and } k = 2, 3, \ldots, 7 \quad (10)$$

5. Results

5.1 Model for mediators

The analysis started by examining whether subjective well-being at *t*-1 is significantly related to the mediators at *t*-1. The findings indicate that those who have higher levels of overall life satisfaction and mental health have significant effects on lifestyle choices and social capital (see Tables 3 and 4). Looking across columns 2 to 7 in Table 3, we can see that overall life satisfaction is significantly related to the possible mediators, with the exception of smoking and drinking

alcohol. Those who are highly satisfied with their lives tend to enjoy more physical activity and social interaction. Moreover, they are more likely to spend more time on outdoor tasks and participate more in volunteer or charity work.

Our second type of subjective well-being measure was mental health. Columns 2 to 7 in Table 4 show that better levels of mental health have significant effects on lifestyle choices and social capital, increasing enjoying physical activity and social interaction, and spending time in outdoor tasks while decreasing smoking frequently.

5.2 Direct and indirect effects: Mediation analysis

We now turn to examine whether the mediators at t -1 relate to our outcome variable of interest, physical health at t. Column 1 in Tables 3 and 4 shows that past physical activity and past volunteer or charity work are positively related to present physical health and statistically significant at least at the 5% level. This implies that people who often exercise and participate more in volunteer or charity work are often healthier.

Our results raise the possibility that physical activity, social interaction, smoking, drinking alcohol, outdoor tasks and volunteer or charity work may partly explain the relationship between past subjective well-being and present physical health (see Table 5 for a summary of the results). Regarding the indirect effects, which is the effect of subjective well-being at t-1 on physical health at t that goes indirectly through the mediators at t-1, it was estimated that the indirect effects for each mediator by multiplying the influence of subjective well-being on the mediator (pathway a_{1j} (j=1 to 6)) with the impact of the particular mediator on an individual's physical health (pathway b_k (k= 2 to 7).). For example, the indirect effect of past overall life satisfaction to present

physical health through the lagged frequency of physical activity is $0.079 \times 0.\ 0589 = 0.0047$ ($a_{11}b_2$). The significant level of this indirect effect is tested by the Sobel test.

As expected, it was found that subjective well-being also has a positive and statistically significant indirect effect on physical health. People who are highly satisfied with their life and their mental health tend to have better physical health through the various possible mediators. Table 5 presents the mediation effects on physical health. Column 1 in Table 5 suggests that the effect of past overall life satisfaction on physical health is significantly mediated by physical activity at p-values < 0.01, while also significant at p-values < 0.1 for volunteer or charity work.

The direct and total indirect effects of overall life satisfaction are positive and statistically significant at p-values < 0.01. The total indirect effect of all six mediators was 9.53% of the total effect. Physical activity is the main mediator, which provided 85.46% of the total indirect effect and 8.19% of the total effect. Unfortunately, volunteer or charity work only explained 3.6% of the total indirect effect.

Consistently, the direct and total indirect effects of mental health on physical health are still positive and statistically significant. Column 2 in Table 5 shows that the link between past mental health and present physical health is also explained by physical activity and volunteer or charity work. The total indirect effect of all six mediators was 10.79% of the total effect. Physical activity is still the main mediator, which provided 90.77% of the total indirect effect and 9.78% of the total effect in the mental health pathway. Volunteer or charity work explained 3.1% of the total indirect effect, although marginally significant at the 10% level.

We may conclude that the mediating effect of past subjective well-being on present physical health is best explained by physical activity. These results indicate that

happy people tend to participate more often in physical activity, which in turn positively influences their physical health.

Table 3. Random effects regression models with control means of time varying for physical health, physical activity, social interaction, smoking, drinking, outdoor tasks and volunteer or charity work (overall life satisfaction pathway).

	Physical health	Frequency of physical activity (t-1)	Frequency of social interaction (t-1)	Frequency of smoking (t-1)	Frequency of drinking (t-1)	Outdoor tasks (t-1)	Volunteer or charity work (t-1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Frequency of physical activity (t-1)	0.0589***						
	(0.00558)						
Frequency of social interaction (t-1)	0.00498						
	(0.00575)						
Frequency of smoking (t-1)	-0.000208						
	(0.0132)						
Frequency of drinking (t-1)	0.00218						
	(0.00771)						
Outdoor tasks (t-1)	0.00261*						
	(0.00149)						
Volunteer or charity work (t-1)	0.00613**						
	(0.00262)						
Overall life satisfaction (t-1)	0.0519***	0.0790***	0.0646***	-0.00213	-0.00315	0.0966***	0.0406***
	(0.00658)	(0.00591)	(0.00558)	(0.00292)	(0.00482)	(0.0220)	(0.0128)
Age	-0.0576***	-0.0179***	-0.0104**	-0.00185	0.0276***	0.0890***	0.0325***
	(0.00612)	(0.00453)	(0.00410)	(0.00348)	(0.00528)	(0.0170)	(0.00945)
Male	0.0168	0.262***	-0.0992***	0.140***	0.664***	2.088***	-0.00941
	(0.0275)	(0.0215)	(0.0195)	(0.0174)	(0.0284)	(0.0832)	(0.0462)
Household size	-0.0227	-0.0457***	-0.0872***	-0.000198	0.00672	-0.0194	0.0365
	(0.0159)	(0.0152)	(0.0139)	(0.00799)	(0.0114)	(0.0523)	(0.0254)
Number of children in the household	0.0720***	-0.0147	-0.0425**	-0.00389	-0.00151	0.0735	0.0399
	(0.0188)	(0.0178)	(0.0167)	(0.00938)	(0.0136)	(0.0644)	(0.0328)
Real household income	0.000224	-0.00000299	-0.000222	0.0000568	0.000161	0.0000987	-0.00118***
	(0.000178)	(0.000162)	(0.000141)	(0.0000617)	(0.000128)	(0.000596)	(0.000418)
Private health insurance	-0.00265	0.00520	-0.0284	-0.00371	-0.0237	-0.0649	-0.0493
	(0.0251)	(0.0237)	(0.0222)	(0.0128)	(0.0180)	(0.0821)	(0.0512)
Living as couple	-0.0381	-0.0796***	-0.293***	-0.0755***	-0.0484*	0.259**	-0.146**
	(0.0330)	(0.0301)	(0.0301)	(0.0186)	(0.0264)	(0.104)	(0.0632)
High education	0.0527	0.0522	-0.0732	-0.0596**	0.0758**	0.0839	-0.0120
	(0.0486)	(0.0489)	(0.0446)	(0.0289)	(0.0354)	(0.131)	(0.104)
Unemployed	0.0354	0.101**	0.142***	0.0164	-0.0872***	1.585***	0.720***
	(0.0450)	(0.0408)	(0.0394)	(0.0228)	(0.0292)	(0.181)	(0.110)
Not in the labour force	-0.322***	0.0113	0.240***	-0.0150	-0.116***	1.395***	0.546***
	(0.0285)	(0.0233)	(0.0213)	(0.0104)	(0.0178)	(0.102)	(0.0656)
Observations	65,937	65,937	65,937	65,937	65,937	65,937	65,937

Note: *p < 0.1, **p< 0.05, ***p< 0.01. Robust standard errors are in parentheses. All models included Australian region of residence dummies and waves as control variable. For models (2)-(7) control variables take on lagged values (t-1) (e.g. Age (t-1), Male (t-1), Household size (t-1), Number of children in the household (t-1), Real household income (t-1), Private health insurance (t-1), Living as couple (t-1), High education (t-1), Unemployed (t-1), Not in the labour force (t-1)).

Table 4. Random effects regression models with control means of time varying for physical health, physical activity, social interaction, smoking, drinking, outdoor tasks and volunteer or charity work (mental health pathway).

	Physical health	Frequency of physical activity (t-1)	Frequency of social interaction (t-1)	Frequency of smoking (t-1)	Frequency of drinking (t-1)	Outdoor tasks (t-1)	Volunteer or charity work (t-1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Frequency of physical activity (t-1)	0.0566***						
	(0.00555)						
Frequency of social interaction (t-1)	0.00330						
	(0.00573)						
Frequency of smoking (t-1)	-0.000325						
	(0.0132)						
Frequency of drinking (t-1)	0.00322						
	(0.00771)						
Outdoor tasks (t-1)	0.00271*						
	(0.00149)						
Volunteer or charity work (t-1)	0.00615**						
	(0.00262)						
Mental health (t-1)	0.0538***	0.105***	0.0782***	-0.00206	-0.0135***	0.0563***	0.0322***
	(0.00617)	(0.00538)	(0.00487)	(0.00252)	(0.00428)	(0.0187)	(0.0109)
Age	-0.0702***	-0.0221***	-0.0154***	0.0000415	0.0267***	0.0864***	0.0301***
	(0.00586)	(0.00449)	(0.00406)	(0.00347)	(0.00528)	(0.0170)	(0.00944)
Male	-0.0936***	0.219***	-0.149***	0.158***	0.656***	2.061***	-0.0338
	(0.0257)	(0.0213)	(0.0194)	(0.0174)	(0.0284)	(0.0828)	(0.0463)
Household size	-0.0234	-0.0456***	-0.0872***	-0.000196	0.00664	-0.0198	0.0364
	(0.0157)	(0.0152)	(0.0139)	(0.00799)	(0.0114)	(0.0523)	(0.0254)
Number of children in the household	0.0714***	-0.0143	-0.0426**	-0.00385	-0.00199	0.0705	0.0390
	(0.0186)	(0.0178)	(0.0167)	(0.00938)	(0.0136)	(0.0644)	(0.0327)
Real household income	0.000229	0.0000357	-0.000191	0.0000558	0.000158	0.000135	-0.00117***
	(0.000176)	(0.000163)	(0.000141)	(0.0000617)	(0.000128)	(0.000596)	(0.000417)
Private health insurance	-0.000610	0.00562	-0.0281	-0.00372	-0.0237	-0.0648	-0.0492
	(0.0250)	(0.0236)	(0.0221)	(0.0128)	(0.0180)	(0.0821)	(0.0512)
Living as couple	-0.0337	-0.0753**	-0.288***	-0.0758***	-0.0467*	0.279***	-0.139**
	(0.0328)	(0.0299)	(0.0300)	(0.0186)	(0.0264)	(0.104)	(0.0630)
High education	0.0553	0.0511	-0.0743*	-0.0596**	0.0756**	0.0804	-0.0132
	(0.0484)	(0.0482)	(0.0444)	(0.0289)	(0.0354)	(0.131)	(0.104)
Unemployed	0.0435	0.105***	0.143***	0.0164	-0.0891***	1.575***	0.718***
	(0.0449)	(0.0405)	(0.0392)	(0.0228)	(0.0292)	(0.182)	(0.110)
Not in the labour force	-0.320***	0.0179	0.245***	-0.0152	-0.117***	1.398***	0.548***
	(0.0284)	(0.0232)	(0.0212)	(0.0104)	(0.0178)	(0.102)	(0.0657)
Observations	65,937	65,937	65,937	65,937	65,937	65,937	65,937

Note: The same footnote as for Table 3 applies.

Table 5. Mediation effects on physical health

	Physical health mediation	
	Overall life satisfaction pathway	Mental health pathway
	(1)	(2)
(A) indirect physical activity	0.0047***	0.0059***
	(0.0006)	(0.0007)
(B) indirect social interaction	0.0003	0.0003
	(0.0004)	(0.0004)
(C) indirect smoking	0.0000004	0.000001
	(0.00003)	(0.00003)
(D) indirect drinking	-0.00001	-0.00004
	(0.00003)	(0.0001)
(E) indirect outdoor tasks	0.0003	0.0002
	(0.0002)	(0.0001)
(F) indirect volunteer or charity work	0.0002*	0.0002*
	(0.0001)	(0.0001)
(A + B + C + D + E + F) total indirect effect	0.0055***	0.0065***
	(0.0011)	(0.0012)
(G) direct effect	0.0519***	0.0538***
	(0.00658)	(0.00617)
(A) + (B) + (C) + (D) + (E) + (F) + (G) total effect	0.0574	0.0603
Total indirect / total effect	9.53%	10.79%
Observations	65,937	65,937

Note: The pathway in the model (1) is lagged overall life satisfaction with the outcome physical health. The pathway in the model (2) is lagged mental health with the outcome physical health. The Sobel test provides an approximate estimate for the indirect effect of the lagged overall life satisfaction and lagged mental health on the outcome physical health via the mediators; *p < 0.1, **p< 0.05, ***p< 0.01.

6. Robustness checks

This section checks in several ways whether the results found previously are robust in different circumstances; first, to test whether gender differences matter in this study. The study found that past overall life satisfaction and past mental health improve the present physical health of both males and females. Second, a potential concern is that individuals with relatively low levels of mental health or overall life satisfaction are more

likely to drop out of the panel survey over time, using a balanced panel of those respondents who participated in all 13 waves used in this study. The findings indicate that even in this smaller sample (of approximately 14.7% of the initial observations), the estimates are very similar to those using an unbalanced panel. Finally, the authors are particularly interested in the following questions for the older population: Are the results found in the 2017 Ohrnberger et al. study of older people similar to those found in this study? The present study focused on the older population aged 50 years and above and used three mediator variables in the model. The findings are consistent with Ohrnberger et al. (2017), who found that the direct and indirect effects of past overall life satisfaction and past mental health positively influence present physical health for older people and that past physical activity is a strongly important mediator in the model.

7. Conclusion

This paper has examined the direct and indirect effects of subjective well-being on physical health using mediation analysis. Subjective well-being is captured by two separate measures: one for overall life satisfaction and one for mental health. Importantly, the authors performed a mediation analysis to investigate whether six mediators mediate the causal effect of the relationship between subjective well-being on physical health. The six mediators are (i) frequency of physical activity, (ii) frequency of social interaction, (iii) frequency of smoking, (iv) frequency of drinking alcohol, (v) hours spent on outdoor tasks, and (vi) hours spent on volunteer or charity work. Besides, the authors used large-scale population data for Australia and a large number of waves to estimate random effect specification by including the individual-specific means of the time-varying variable as

additional control variables in order to proxy the fixed-effect (e.g., Mundlak, 1978). Analysis revealed that past subjective well-being has positive direct and indirect effects on present physical health. This indirect effect is best mediated by past physical activity. Those who are highly satisfied with their life and their mental health tend to enjoy more physical activity, which in turn positively influences their physical health.

In terms of overall life satisfaction, it was found that the total indirect effect provided 9.53% of the total effect on present physical health. Physical activity is the main mediator, which provided 85.46% of the total indirect effect and 8.19% of the total effect. For mental health, findings indicate that the total indirect effect accounts for about 10.79% of the total effect on present physical health. Similarly, physical activity explains the main share, accounting for approximately 90.77% of the total indirect effect and 9.78% of the total effect. This finding is consistent with Ohrnberger et al. (2017), who found that the total indirect effect accounts for 9.7% of the total effect of mental health on present physical health.

Most of the previous studies do not conduct a mediation analysis and the effect of individual well-being on physical health. Ohrnberger et al. (2017) found that the effect of past mental health on physical health is mediated by physical activity and social interaction. However, they focused on an older population aged 50 years and above and used three mediator variables (i.e., physical activity, cigarette consumption, and social interaction) while ignoring some important mediators, which may affect physical health. Importantly, they did also not consider overall life satisfaction. The findings in the present study add new information to existing literature and suggest that overall life satisfaction directly influences physical health and indirectly (via some mediators) influences physical health. The key mediators are different from the existing literature; the presented study

utilised more mediator variables. In sum, physical activity is the largest contributor to the total indirect effect.

This study is not without shortcomings. One limitation is that the mediation analysis accounted for only six possible pathways. Dietary choices and medical care, which are not considered here, may also be important. One implication of this is that we can capture an upper bound of the direct effects of subjective well-being and a lower bound of its indirect effects (e.g., Ohrnberger et al., 2017). Further studies are, therefore, needed in order to consider a broader set of mediators.

Good health results not only from medical care but also from any healthy public policy for all people. Therefore, this paper would provide support for encouraging certain behaviour and activity in daily life, and it could be useful particularly for policymakers in aiding the design of health policies that promote an individual's physical health. Building healthy public policy is the process of developing policies that support health by not only protecting the health of individuals and communities but also making it easier for people to make healthy choices. The policymakers should set out the ultimate well-being objectives in policies and how they plan to deliver them. Healthcare policies are not made just by health departments but by all levels and sectors of government and other organisations, even if only indirectly. For example, laws requiring people to wear their seatbelts and helmets, and implementing smoking restrictions and workplace health and safety regulations are examples of public healthcare policies. In this paper, the key pathway is physical activity that should be considered, as it matters not only as a direct effect but also an indirect effect between overall life satisfaction (or mental health) and physical health. To promote physical activity, the government should provide more green spaces and make it easier to walk and cycle, both of which have potential benefits

for public health. In particular, more green spaces should be provided in the areas of the city with small or no green spaces, adding more attractive activities, such as yoga, running race, and cycling race.

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