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Green investment and its influence on green growth in high polluted Asian economies: Do financial markets and institutions matter?

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ABSTRACT

The notion of green growth has occurred as a leading policy response to environmental pollution. This study explores the dynamic impacts of green investment, financial institutions & markets on green growth based on a time series data set comprised of four high polluted Asian countries from 1995 to 2019. We found several important short and long-run results from the ARDL bounds testing approach. First, green investment has a positive long-run effect on green growth in China, India, and Russia. Second, financial institutions have positive long-run effects on green growth in China, India, and Japan; but financial markets improve only in China and Russia. The findings also propose that internet users and R&D foster green growth in mostly high polluted Asian countries. Thus, our findings offer some implications for high polluted Asian countries to stimulate green growth in the future.

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1. Introduction

The future of humanity depends on the attainment of sustainable development, which requires the successful implementation of policies and strategies that can reduce greenhouse gas (GHG) emissions. GHG emissions, particularly CO2 emissions, are considered to be the most crucial hurdle in the way of attainment of sustainable development (IPCC, 2014). The industrial revolution proved to be the turning point in world history. On one side, it helped the economies to grow rapidly; on the other side, it was the major cause of CO2 infusion into the atmosphere and environmental degradation. In recent times, climate change and global warming have become the primary concern of people around the globe (Ahmad et al., 2021). Furthermore, the

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anthropogenic pressure causes the exploitation of natural resources to rise, leading to environmental deterioration (Dogan & Inglesi-Lotz, 2020).

According to Canadell et al. (2007), the rising human activities are mainly responsible for increasing global average temperatures, which is the ultimate cause of environmental degradation. Therefore, governments all around the globe are working together and making pledges to reduce environmental pollution. In this regard, world leaders have signed various agreements to control CO2 emissions and resulting environmental degradation, such as the Kyoto Protocol in 1997, and the most important of all agreements, the Paris Climate Agreement (PCA) in 2015. These pacts are considered vital if the world wants to move towards a cleaner environment and green growth. The primary focus of these agreements is to attract the attention of policymakers and governments towards a sustainable environment for this and upcoming generations (Li et al., 2022). The PCA asked the member countries to make combined efforts to keep the growth of the world's average temperature below 2 °C. Conclusive actions are required on the part of member countries; particularly, promoting carbon-free and renewable energy sources could prove vital.

In the context of environmental protection, the idea of green growth emerged in 2012, during the Rio+ 20 conference. At the end of the conference, an agenda document with the title 'The World We Want' (UN 2012) stressed two main goals such as 'green economy and a 'sustained economic growth'. Since then, the idea of green growth has been adopted by leading multinational firms, and it has become the part and parcel of the environmental protection policies at national and international levels. The theory of green growth believes that decoupling economic growth from carbon emissions and resource utilisation is entirely possible (Hickel & Kallis, 2020). In the development economics theoretical and empirical literature, human capital is observed as a vital driver of economic growth (Romer 1986, Ishfaq et al., 2022). More importantly, at a rate that is appropriate to slow down the effects of climate and global warming.

Rising trends in consumption and production activities, due to an increase in investment, escalate economic growth, which also causes CO2 emissions to rise (Ozturk & Ullah, 2022). In this context, investment in mega infrastructure projects has become a popular agenda in the eyes of policymakers in Asian economies (Gao et al., 2022). The role of investment is becoming crucial for encouraging or controlling CO2 emissions. According to an estimate, per year investment of US$ 1.7 trillion, or a total investment of US$ 26 trillion, is necessary to control the menace of poverty, stimulate growth, and deal with the problem of climate change between 2016 to 2030 (Sachs et al., 2019) . Out of the total investment, almost US$ 14.7 trillion needs to be invested in the power sector, US$ 8.4 trillion in the transportation sector, US$ 2.3 trillion in the telecommunication sector, and US$ 800 billion in the water and sanitation sector (Wang et al. 2020).

Given the importance of a sustainable environment and green growth, policymakers are now focussing on transforming energy structure from dirty energy (e.g., coal, oil, and gas) to clean energy (e.g., wind, solar, biofuel, and nuclear). The transformation of energy structure mainly depends on green financing and pricing the externalities (Li & Ullah, 2022; Li et al., 2022). However, pricing the emissions is not enough to tackle the issue of environmental sustainability (OECD, 2018). The IMF also highlighted that pricing the externalities might not be sufficient to cope with the threat of global warming and climate change (Lagarde & Gaspar, 2019). Mazzucato and Semieniuk (2018) postulated that a rise in public investments in the shape of green financing could prove to be significant in controlling carbon emissions and developing a more efficient energy system. In other words, we can say that financial policies help mobilise private investment to speed up the low carbon transition process (Ullah et al., 2021). In order to decouple the environmental pollution from economic growth, policymakers worldwide are relying on green investment to mitigate the effects of environmental pollution and to provide funds for converting countries from carbon-intensive to low-carbon economies. Rising demand for low-carbon projects requires the policymakers to implement suitable policies such as investment in green bonds, a new financial instrument, can be helpful to combat the problem of climate change (Lei et al., 2022). In short, green investment can come out as a crucial and significant strategy in decoupling economic growth and environmental deterioration (Wang & Zhi, 2016 and Chen & Ma, 2021). Therefore, the role of banking and other financial institutions can increase manifold because they can provide the necessary funds to achieve the target of green growth. Definition of green investment provided by Höhne et al. (2012) defined green investment as a type of investment that can protect the environment and promote green growth by encouraging green projects and initiatives.

Asia is the most polluted continent on the planet, and China, India, Japan, and Russia are among the highly polluted economies of Asia. Moreover, these are among the top economies in terms of GDP. China, India, and Russia are members of the BRICS economies and strive to follow green practices in their manufacturing and production process, which is vital in moving towards the path of sustainability. On the other side, Japan is a member of the G7 economies, a developed economy, and has already done a lot to mitigate carbon emissions and achieve sustainable development (UNEP, 2020). Therefore, our primary focus is to investigate the impact of green investment on green economic growth in highly polluted economies. Moreover, we also want to focus on the impact of the financial market and institutions on green economic growth in highly polluted nations of Asia. Hence, this is the first study that has tried to analyse the nexus between green investment and green growth in the context of the highly polluted economies of Asia. Previously, all studies have focussed on panel data analysis suffers from the problem of aggregate bias; while, the time series analysis is free from such issues. Moreover, all previous studies have only focussed on the long-run results; however, we provide the short and long-run results in this analysis. Therefore, for empirical estimation of the model, we rely on the ARDL model.

2. Model and methods

Following earlier literature Jacobs (2012), Song et al. (2019), Hickel and Kallis (2020), Li and Liao (2020), we assume that the main determinants of green growth are green investment, financial markets and institutions, internet, and research & development. Therefore, we begin with the following econometric models:

$$GG_t = \pi_0 + \pi_1 GI_t + \pi_2 FD_t + \pi_3 Internet_t + \pi_4 RD_t + \varepsilon_t \tag{1}$$

Equation (1) is green growth that depends on green investment (GI), financial development (FD), including financial markets and institutions, internet users (internet), and research & development (RD). The rise in green investment and financial markets and institutions also improve sustainability by increasing their green economic growth. One main limitation of the above equation (1) is its ability to provide only long-run estimates. However, the objective of the analysis is to evaluate the short- and long-run impacts. To that end, we have taken recourse to the ARDL of Pesaran et al. (2001), which can investigate both short and long-run impacts. The first step of the ARDL is to express the above equation (1) into error correction format as follows:

$$\begin{aligned}\Delta GG_t = {} & \pi_0 + \sum_{k=1}^{n} \beta_{1k} \Delta GG_{t-k} + \sum_{k=0}^{n} \beta_{2k} \Delta GI_{t-k} + \sum_{k=0}^{n} \beta_{3k} \Delta FD_{t-k} \\ & + \sum_{k=0}^{n} \beta_{4k} \Delta Internet_{t-k} + \sum_{k=0}^{n} \beta_{5k} \Delta RD_{t-k} + \pi_1 GG_{t-1} + \pi_2 GI_{t-1} + \pi_3 FD_{t-1} \\ & + \pi_4 Internet_{t-1} + \pi_5 RD_{t-1} + \lambda . \ ECM_{t-1} + \varepsilon_t\end{aligned} \tag{2}$$

Equation (2) has now become the ARDL model, which has the power to provide both short and long-run effects. From equation (2), the short-run effects are derived through the estimates of the first-difference variables, and the long-run estimates are the ones that are derived from the estimates $\pi_2 - \pi_5$ normalised on π_1. As for the long-run estimates are concerned, they can be susceptible to spurious regression; hence, cointegration is a mandatory condition for valid long-run estimates. For that purpose, Pesaran et al. (2001) proposed a bounds F-test for the combined significance of lagged level variables. They also proposed another test known as ECM or t-test that indicates the valid long-run relationship if the estimates of λ are negatively significant. However, the F-test and t-test rely on new critical values developed by Pesaran et al. (2001). Among the many advantages of the ARDL model, the most prominent one is its ability to deal with variables with different orders of integration, such as I(1), I(0), and a blend of both. Hence, pre-unit root testing is not mandatory when we apply the ARDL model. Furthermore, the limited number of observations is a problem when dealing with the time series analysis; however, the ARDL model can also take care of this problem. Finally, the short-run dynamic process is included in the model that can estimate is crucial in resolving the problems of serial correlation and endogeneity (Usman et al., 2021). In addition, we have applied some diagnostic checks to keep our results free from any suspicion. These tests include LM, BP, and Ramsey's RESET for detecting serial correlation, heteroscedasticity, and functional misspecification. Last but not least, CUSUM and CUSUM^2 tests are famous for their ability to test the stability of the parameters, and the analysis took benefit of it by applying these tests.

Table 1. Data and sources

Variables	Symbol	Definitions	Sources
Green growth	GG	Environmentally adjusted multifactor productivity	OECD
Green investment	GI	Total nuclear, renewables, and other production (quad Btu)	EIA
Financial institutions development	FID	Financial institutions development index	IMF
Financial markets development	FMD	Financial markets development index	IMF
Internet users	Internet	Individuals using the Internet (% of population)	World bank
Research and development	RD	Research and development expenditure (% of GDP)	World bank

Source: Authors own calculations.

3. Data

The current study intends to explore the effect of green investment, financial markets development, and financial institutions development on green growth of highly polluted Asian economies from 1995 to 2019. Highly polluted Asian economies include China, India, Japan, and Russia. Table 1 contains information regarding definitions and sources of data. The dependent variable, green growth is measured as environmentally adjusted multifactor productivity and the data is taken from OECD. Green investment is measured by total nuclear, renewables, and others production in quad btu, and the data has been extracted from EIA. Data for financial institutions development index and financial markets development index have been explored from the IMF. Besides these variables, internet users and research & development are taken as control variables. Internet users are taken in percent of the population while R&D expenditures are taken in percent of GDP. Data for both control variables have been extracted from the World Bank. The economy-wise descriptive statistics are reported in Table 2.

4. Results and discussion

Before starting regression analysis, the first step is to confirm the stationarity properties of the data. For this purpose, the study adopted Dickey-Fuller Generalized Least Square (DF-GLS) approach. Table 2 contains the outcomes of DF-GLS test, and it is found that there is mixed order of integration among variables, that is, a mixture of I(0) and I(1) order of integration. However, none of the variables are found stationary at the second difference. In the next step, the study employed ARDL approach for empirical inquiry of the objectives. Table 3 reports the estimates of the green growth model in which green investment and financial institutions' development are major focussed variables, whereas Table 4 displays the estimates of the green growth model, where green investment and financial market development are major independent variables.

In Table 3, long-run findings display that green investment brings significant and positive impacts on green growth in China, India, and Russia. It infers that a 1% increase in green investment increases green growth by 0.064% in China, 0.816% in India, and 0.170% in Russia. The impact of financial institutions' development on green growth is observed significant and positive in China, India, and Japan in the long-run. It reports that a 1% expansion in financial institutions development brings an upsurge in green growth by 3.895% in China, 2.077% in India, and 0.202% in Japan. Although all these economies are highly polluted, it is observed that green

Table 2. Descriptive statistics and unit root test

	Descriptive statistics					Unit root test		
	Variables	Mean	Std. Dev.	Min	Max	I(0)	I(1)	Decision
China	GG	8.920	1.301	7.103	13.13	−2.707*		I(0)
	GI	7.938	6.105	2.062	21.37	6.893	−2.786*	I(1)
	FID	0.755	0.034	0.701	0.799	−1.251	−3.345**	I(1)
	FMD	0.970	0.062	0.777	1.000	−2.649*		I(0)
	Internet	24.00	22.64	0.005	64.56	−2.636*		I(0)
	RD	1.424	0.579	0.447	2.328	−0.717	−4.527***	I(1)
India	GG	6.183	1.826	2.474	9.242	−4.433***		I(0)
	GI	1.641	0.720	0.804	3.342	2.537	−3.741*	I(1)
	FID	0.602	0.034	0.514	0.643	−2.853*		I(0)
	FMD	0.837	0.175	0.576	1.000	−1.448	−5.734***	I(1)
	Internet	7.630	9.472	0.026	41.00	−2.672*		I(0)
	RD	0.730	0.062	0.639	0.859	−1.123	−3.688**	I(1)
Japan	GG	1.117	1.732	−4.600	4.743	−5.725***		I(0)
	GI	3.390	1.095	1.516	4.533	−0.982	−3.412**	I(1)
	FID	0.739	0.037	0.672	0.785	−2.454	−6.932***	I(1)
	FMD	0.897	0.198	0.396	1.000	−2.875*		I(0)
	Internet	60.53	31.06	1.594	93.18	−2.941*		I(0)
	RD	3.110	0.210	2.687	3.400	−1.982	−3.873***	I(1)
Russia	GG	4.063	3.678	−4.730	9.499	−3.574***		I(0)
	GI	3.294	0.334	2.700	3.863	−0.105	−5.511***	I(1)
	FID	0.435	0.122	0.265	0.727	−1.668	−6.202***	I(1)
	FMD	0.663	0.223	0.280	0.965	−0.741	−6.667***	I(1)
	Internet	32.94	31.07	0.148	82.64	0.997	−3.468**	I(1)
	RD	1.078	0.093	0.910	1.286	−2.915*		I(0)

Note: ***$p < 0.01$; **$p < 0.05$; and *$p < 0.1$
Source: Authors own calculations.

Table 3. ARDL estimates of green growth

Variable	China Coefficient	t-Stat	India Coefficient	t-Stat	Japan Coefficient	t-Stat	Russia Coefficient	t-Stat
Short-run								
D(GI)	0.045**	2.284	0.058	1.314	0.058***	4.620	0.063	1.095
D(GI(-1))	−0.042**	2.022			0.025	1.234		
D(GI(-2))					−0.025	1.650		
D(FID)	2.082***	3.967	0.471**	2.113	0.046	0.184	−0.030	0.824
D(FID(-1))					0.387	1.462		
D(INTERNET)	0.001	0.314	0.003**	2.008	0.003***	2.801	0.003***	2.726
D(INTERNET(-1))							0.003**	2.461
D(RD)	0.224*	1.892	0.148	1.585	−0.028	0.192	0.128**	2.043
D(RD(-1))	0.281**	2.116			−0.108	0.898		
Long-run								
GI	0.064**	2.083	0.816***	9.814	0.006	0.507	0.170***	3.062
FID	3.895***	3.756	2.077**	2.550	0.202**	2.331	−0.037	0.845
INTERNET	0.016*	1.731	0.014**	2.263	0.003**	2.176	0.001*	1.832
RD	0.854***	3.691	0.655	1.387	0.389*	1.713	0.154*	1.790
C	10.06***	8.556	11.39***	5.712	15.08***	3.165	3.880***	5.952
Diagnostics								
F-test	4.196*		2.334		5.875***		7.968***	
ECM(-1)	−0.353***	3.221	−0.227***	−3.281	−0.537***	4.318	−0.430***	5.580
LM	1.189		0.301		1.985		1.652	
BP	1.452		1.630		1.587		0.598	
RESET	1.235		0.165		0.355		0.569	
CUSUM	S		S		s		S	
CUSUM-sq	S		S		US		S	

Note: ***$p < 0.01$; **$p < 0.05$; and *$p < 0.1$
Source: Authors own calculations.

Table 4. ARDL estimates of green growth

Variable	China Coefficient	t-Stat	India Coefficient	t-Stat	Japan Coefficient	t-Stat	Russia Coefficient	t-Stat
Short-run								
D(GI)	0.021	0.029	0.079**	2.066	0.051***	3.884	0.009	0.168
D(GI(-1))			0.058	1.057	0.022	1.045		
D(GI(-2))					−0.026*	1.796		
D(FMD)	0.550***	2.836	−0.007	0.107	0.021	0.293	0.084**	2.025
D(FMD(-1))			0.125***	2.596				
D(INTERNET)	0.005	0.618	0.003*	1.941	0.003**	2.229	0.003**	2.210
D(INTERNET(-1))	0.011	1.450					0.003**	2.263
D(RD)	0.290**	1.963	0.205	1.147	−0.103	0.849	−0.088	1.593
D(RD(-1))			−0.476***	2.725	−0.042	0.366		
Long-run								
GI	0.051**	2.029	0.773***	3.299	0.014	0.808	0.082*	1.816
FMD	0.987***	4.276	−0.175	0.337	0.028	0.302	0.163***	2.693
INTERNET	0.011*	1.675	0.019*	1.672	0.044*	1.894	0.001*	1.764
RD	1.163***	7.728	2.520**	2.279	0.529*	1.887	0.094	1.433
C	3.245***	9.908	11.55***	4.547	5.267***	2.461	3.924***	5.486
Diagnostics								
F-test	4.578*		4.758*		3.145		10.12***	
ECM(-1)	−0.557***	3.556	−0.271**	2.024	−0.648***	3.466	−0.739***	6.322
LM	1.658		1.854		1.985		0.322	
BP	0.698		0.230		1.235		1.755	
RESET	0.545		0.074		0.366		0.158	
CUSUM	S		S		S		S	
CUSUM-sq	S		S		US		S	

Note: ***$p < 0.01$; **$p < 0.05$; and *$p < 0.1$
Source: Authors own calculations.

investment policies and expansion of financial institutions' development can result in enhancing green growth that ultimately works for pollution reduction in these countries.

Shen et al. (2021) support our findings by arguing that green investment tends to enhance the effectiveness of climate markets and energy system that contributes significantly to promoting green growth. Thus, an increase in green investment enhances the production effectiveness of organisations and promotes the consumption of renewable energy sources, and hence, reduce the negative effect of production activities on climate and increasing green growth. Moreover, green investment results in improving environmental quality by enhancing the capability of technological innovation, energy savings, and improvement of industrial structure, which, in turn, enhances green growth. Wang et al. (2021) support our findings by concluding that green investment enhances the technology innovation that results in the alleviation of carbon emissions during the process of production, and thus enhances green growth. Another study supports our findings by arguing that green investment can minimise the financial expenses of environmental protection, expand financial support to industries, and provide capital flow to industries, thus contributing to enhancing green growth (Zhou et al., 2022). Our findings are in line with the study done by (Mahat et al., 2019), which states that financial institutions' development enhances green growth, as it empowers industries to use advanced machinery, which is eco-friendly and contributes to promoting green growth. Financial institutions development provides affordable short-term financing to investors, which is required to stimulate the process of green growth.

In the long-run, impact of internet is significant and positive on green growth in all four selected economies, while R&D report a significant and positive impact on green growth in case of China, Japan, and Russia. This finding is also supported by Lin and Benjamin (2017), who noted that R&D improvement also significantly leads to green growth. In the short-run, findings reveal that impact of green investment on green growth is significant and positive in China and negative and significant in Japan. However, financial institutions development reports a significant and positive impact on green growth in China and India in the short-run. Internet brings a significant and positive increase in green growth in India, Japan, and Russia in the short-run. While the impact of research and development is observed significant and positive on green growth in China and Russia in the short-run. In the lower panel, coefficient estimates of diagnostic tests are given for all four models, which include ECM, F-statistics, RESET test, BP, LM, and CUSUM and CUSUM-sq tests. The long-run co-integration association among variables is confirmed by the findings of ECM and F-stat results. While LM and BP tests confirm the absence of heteroscedasticity and autocorrelation problems, the CUSUM tests stated that our parameters are stable where 'S' means stable and 'US' means unstable. Meanwhile, normality is also observed in the findings of Ramsey RESET results.

In Table 4, long-run findings reveal that the impact of green investment is significant and positive on green growth in case of China, India, and Russia. Findings show that a 1% upsurge in green investment raises green growth by 0.051% in China, 0.773% in India, and 0.082% in Russia in the long-run. The impact of financial markets development is found significant and positive on green growth in case of China and Russia in the long-run. It implies that an increment in financial markets development results in increasing green growth by 0.987% in China and 0.163% in Russia. Our findings also infer that financial markets development enhances green growth through technological innovation and green investment. Financial markets development is the backbone of green growth as it plays a vital role in the provision of required financial resources for making growth. Qin et al. (2021) argued that a well-developed financial system, either financial markets development or financial institution development, can deliver better risk hedging and risk diversification services and significantly reduce the risk of investors regarding technological innovation, hence promoting green growth. Financial markets affect green growth mainly through green investment and technological progress. The financial markets are playing a crucial role in providing essential financial resources as it is the backbone of the green economy.

The internet impact is found significant and positive on green growth in case of all economies. However, research and development impact is significant and positive on green growth in case of China, India, and Japan. In the short-run, findings display that green investment shows a significant and positive impact on green growth in case of India and Japan, while financial markets development reports a significant and positive impact on green growth in case of China and Russia. In case of control variables, it is found that the internet brings a significant and positive impact on green growth in case of India, Japan, and Russia, while research and development report a significant and positive impact on green growth in case of China only in the short-run. In the lower panel, diagnostic tests findings show that there is no issue of heteroscedasticity and autocorrelation found in the models, and the normality condition holds in all the models. Moreover, models are stable and long-run co-integrating exists among variables of interest.

5. Conclusion and implications

Goal 13 of the sustainable development goals asks the countries to take quick and prompt actions to control the menace of global warming. With the advent of the idea of green growth, which refers to carbon-free growth activities, it has become the most plausible option to deal with the problem of global warming. Green investment and financial institutions can play an important role in this regard. Therefore, the analysis aims to examine the influence of green investment on green growth in high polluted Asian economies. Moreover, we also analyse the role of financial markets and institutions in attaining green economic growth because well-functioning and dynamic financial markets provide necessary funds and credits for green investment and technologies that help to achieve green economic growth. Since the analysis relies on the ARDL model, which is quite an efficient method when dealing with a limited number of observations. Two models are used to see the impact of green investment on green economic growth; one with financial institutions and the other with financial markets.

From the estimates of the ARDL model, we confer that the long-run estimates of green investment are positive and significant in China, India, and Russia in both financial institutions and financial markets models. Similarly, the long-run estimated coefficient of the Internet appeared to be positive and in all four countries in financial institutions as well as financial markets models. The long-run estimates of research and development are positive and significant in China, India, and Japan in the financial market models; whereas, in China, Japan, and Russia in the financial institutions model. However, the long-run estimates of financial markets development are significant and positive in China and Russia only, and the estimates of financial institutions development are positively significant in China, India, and Japan. Overall, our results imply that green investment positively contributes to attaining green growth, and the role of financial institutions and markets is also positive. The bounds F-test and ECM_{t-1} test confirm the validity of our long-run results by proving co-integration. In short-run, the estimates of both the models are mixed and inconclusive.

Based on the above findings, we also provide some vital policy directions. The first step towards green economic growth is to decouple carbon emissions from rising industrial production. In order to limit carbon emissions and boost the resilience of the Asian economies, governments in polluted Asian economies must provide funds for encouraging the use of low-carbon energy sources and technologies by issuing green bonds. If Asian economies can successfully adopt mitigating measures and finance green projects, the dream of attaining green growth can become a reality in the near future. Moreover, private investment can play a crucial role in achieving green growth and low carbon transformation. Therefore, green financing should focus more on private investment as well as public-private partnership projects. Dynamic and vibrant financial markets and institutions can play a crucial role in dispersing funds for green investment to both the public and private sectors. Therefore, policymakers should also try to enhance the participation of financial institutions in achieving a green economy via green investment. Furthermore, banks and other financial should provide funds and credits in easy instalments for the deployment of renewable energy projects and green technologies.

Disclosure statement

No potential conflict of interest was reported by the authors.

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