



The Production Diversity effect on Real and Nomial Income with VAR Model

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ABSTRACT

Diversifying in agriculture production helps to ensure the intake of essential nutrients needed for good health, and it is particularly important for households in different areas. Diversification of farm production is recommended as a potential strategy to improve the diet diversity and nutrition of households. Risk management in the agricultural sector must therefore be taken into account during policy formulation and planning. The present study spanned the years 1990 to 2022. The assessment of the degree to which crop diversity mitigates risk was conducted utilizing the Herfindahl index. Using the Hodrick–Prescott filter, the income fluctuations were subsequently computed. The income risk associated with five crops was assessed by calculating the discrepancy between the Hodrick–Prescott and the generated income in nominal and fixed modes. Finally, the vector autoregression (VAR) was utilized to estimate the effect of crop diversity on two modes of risk to farmer income. The results indicate that there is a long-term correlation between crop diversity and decreased income risk. Additionally, the results indicated that agricultural income was temporarily impacted by the fluctuation shock. To achieve nominal and real shock equilibrium, 4 and 3 cycles were required, correspondingly.

Keywords: Crop Diversity, Income Risk, Risk Management Strategy, Uncertainty, Vector Autoregression (VAR).



1. Introduction

Agricultural diversification is widely practiced by farmers. Diversification can serve as a risk management strategy or “natural insurance”, harnessing the buffering effects of different functional farm components. Farm components jointly reduce variation if they respond to time-variant biotic and abiotic stresses in different complementary ways. Also, diversification can reduce market risk when different products have a low correlation between their respective market prices. Diversification support climate adaptation, resilience, and food security. Examples of agricultural diversification are mixed crop-livestock systems, agroforestry, field scattering, varietal diversification, crop diversification, and intercropping (Ahmed and et al, 2021; Raseduzzaman and Jensen, 2017).

Diversification for risk management is important enough to merit support from agricultural research and advisory services. Different types of support are targeted introduction of genetic resources, discovering practices that use certain risk-reducing elements in farm portfolios, supporting policy design to encourage such practices, and opening new marketing channels for alternative products. Diversification does not automatically result in risk-reducing portfolios that address the goals and concerns of the farmers. Despite the importance of diversification for risk management, tools to analyze risk and compose risk-reducing portfolios are still seldom used in farm management or agricultural advisory services (Mesfin and et al, 2011; Van Etten, 2019).

The literature explains the gap between theory and practice by blaming theory rather than practice: tools and analyses are generally too complicated, they focus on isolated aspects of farm risk management, lack contextual validity, make “heroic” assumptions about statistical distributions and uncertainty, produce results that do not match decision-making practice, or lack consideration of communication needs. For practical use in agronomic design and analysis contexts, relatively simple tools are needed to facilitate quick assessment of different portfolios. Normally, the design of agricultural systems does not achieve a single optimal solution but must consider trade-offs for multiple objectives. Farmers will also consider the degree of protection against the risk of other measures, including financial ones, and they shift their farm portfolio accordingly. Therefore, a quick calculation

tool, in combination with other tools, would allow a systematic initial exploration of the solution space (Luo and Cheng , 2022; Wang et al., 2014).

Many studies corroborate crop diversity as an effective risk management strategy, and numerous studies indicate that farmers abstain from taking risks on the whole (Joshi et al., 2004). It is noteworthy to mention that many studies have focused on examining the influence of crop diversity on farmers’ propensity to avoid risk-taking, rather than delving into the degree to which farmers attempt to avoid risk. Crop diversity provides producers and society with additional benefits, including economic, social, and environmental benefits, in addition to risk reduction. Additionally, it enhances soil mineral and nutrient content, prevents erosion, raises the household income of farmers, and contributes to food security (Kankwamba et al., 2018; Ahmed et al., 2021).

In developing countries, crop diversity is a viable alternative for achieving objectives such as increased environmental sustainability, employment creation, and production growth recent developments in Asia, particularly in South West Asia and the MENA regions, suggest that policymakers and authorities have placed a greater emphasis on agricultural development via crop diversity (Mohammad Kani Golzar et al., 2014).

The province of Zanjan comprises 883,000 hectares of arable land, the majority of which is devoted to the cultivation of wheat, colza, lentils, potatoes, and tomatoes. To mitigate the numerous risks that farmers face, including production, market, and price risks, they may implement crop diversity as a policy. This study seeks to investigate the long-term impact of crop diversity on the mitigation of nominal and real income risk among farmers in Zanjan from 1990 to 2022. It also examines the cultivation pattern of the chosen crops.

The motivation and innovation of this study was to examine the role of diversification of production on economic risk, which has been given less attention in Zanjan province.

The present paper was organized into five sections. The second section presents the literature review. The third section provides the research method; In the fourth section, the experimental results are analyzed. Finally, in the fifth section, the results and policy recommendations are elaborated.

2. Theoretical Framework

Agricultural production diversity is an essential means of enhancing diet quality, as more diverse agricultural systems contribute to household diet diversity. In food systems, diversification, defined often as an increase in crop, livestock, production or farming diversity (i.e. agrobiodiversity), has been considered as a key strategy for improving the productivity and stability of many socio-economic and ecological aspects of agricultural systems. It is a central element for example in three areas of research. Firstly, in sustainable intensification, ecological intensification, conservation agriculture (FAO, 2002) and more recently regenerative agriculture. Mixed farming and crop rotations, for example, can support pest, nutrient and water management, reduce external inputs and improve soil biodiversity. Secondly, in research on rural development and sustainable livelihoods as livelihood diversification has often been highlighted as contributing to reduced poverty. And thirdly, in nutrition-sensitive agriculture describing pathways from agriculture to nutrition security where diversification can increase the diversity of foods produced, consumed or sold (Mehrani and et al, 2019). There are two primary pathways from production diversification to better household nutrition. First, diverse food production ensures the availability of diverse food items for individual consumption, which is subsequently likely to improve diet quality and nutrition. Second, diversifying farm production ensures increased and stable income by minimizing market risks in times of price volatility and production output variability, the latter of which is affected by events such as climate change (Mehrani and et al, 2021; Teklegiorgis and et al, 2021).

Uncertainty is synonymous with risk. To quantify uncertainty, risk assessment is required (Hodrick and Prescott, 1997). To ascertain income risk, it is necessary to quantify the level of risk mitigation achieved via crop diversity. Crop diversity is initially assessed using the Herfindahl index:

$$HI = \sum_{i=1}^n p_i^2$$

p_i is each crop's share, which is displayed as Equation 2:

$$p_i = \frac{A_i}{\sum_{i=1}^n A_i}$$

A_i is the area under cultivation for each crop, and $\sum_{i=1}^n A_i$ represents the entire land under cultivation. The value of H ranges from 0 to 1, where 1 denotes a solitary crop and 0 signifies the utmost degree of diversity. Accordingly, an increase in HI is associated with a reduction in crop diversity.

The literature review

Detex and et al (2024) investigated the quantifying food consumption supply risk with an analysis across countries and agricultural products. The results enable a comparison of the supply risk of food consumption between different countries and identification of the products with the highest risk of supply disruption for each country. When analysed by region, the results indicate that North America and Europe generally have lower supply risk across all products than the rest of the world, while African and Sub-Saharan countries tend to have the highest supply risk. Furthermore, the analysis of supply risks for four cereals - wheat, maize, rice, and sorghum - indicates that trade diversification can reduce supply risks for wheat and maize in many countries. However, for rice and sorghum, supply risk reduction will most likely be achieved through stockpiling, export redirection, and adaptation of agriculture to climate change. The results highlight the importance of supply risk indexes for decision-making, particularly when compared to self-sufficiency. Finally, limitations and new perspectives are discussed, including the need to adapt the index to nutritional data, consider competition for agricultural product usage, and refine climate or economic risk indexes.

Hun and Um (2024) studied the risk management strategy for supply chain sustainability and resilience capability. Supply chain sustainability-related risks that have an undesirable environmental, social, and economic impact result in global supply chain uncertainty and complexity. This paper investigates the relationships between supply chain sustainability risks, global uncertainty, and mitigating strategies to attain supply chain resilience capability. The paper suggests the supply chain resilience capability and four fundamental risk-mitigating strategies to cope with supply chain sustainability risks. Data collected via survey were employed for structural equation modeling and moderation tests to explore appropriate mitigating strategies for differing sustainability risk environments. The results suggest a structural

procedure for better supply chain resilience under diverse sustainability risks. Inspired by the literature gap, the study empirically examines how sustainability risks and global uncertainty influence supply chain resilience and provides the most effective risk management strategies among accept, avoid, control, share/transfer according to different sustainability risks. There is a lack of empirical research investigating how to address the supply chain sustainability risk through the provision of effective mitigating strategies for better supply chain resilience capability. The results provide insight for future research in supply chain resilience and sustainability studies.

Von Czettritz et al. (2023) assess the effectiveness of adapting crop rotations on arable farms in Brandenburg as a tool to enhance climate resilience. Two risk-minimizing measures are investigated: crop diversification and the inclusion of irrigated crops. Based on state-wide simulated yield data, the study compares two different scenarios. In the first scenario, the most profitable crop rotations based on predicted future weather conditions are chosen for each agroecological zone. In the second scenario, cropping plans are derived based on an adaption of the Target MOTAD (Minimization of Total Absolute Deviation) model taking climate-induced risks into account. A comparison of the scenarios shows a high-risk reduction effect of diversification, while the economic risk reduction effect of irrigation only increases slightly. The trade-off between the highest possible gross margins and lower possible losses varies depending on the soil and climate conditions. Diversification contributed most to economic resilience in areas with moderate to low agricultural productivity. Subsidies focusing on diversification in less productive areas might be a tool to increase economic resilience with low risk-avoidance costs.

Waha and et al (2022) investigated the benefits and trade-offs of agricultural diversity for food security in low- and middle-income countries. This review aims to give an overview of the strength and direction of the diversity-food security relationship as presented in research published since 2010, based on a comprehensive search in Web of Science. They present an overview and synthesize results for different spatial scales and units of observation, from individual to global and for the four dimensions of food security: availability, access, stability and

utilisation. Eighty-eight of the 924 surveyed publications meet the inclusion criteria and report the direction and magnitude of 314 individual diversity-food security relationships. In almost two thirds of all cases, agricultural diversity had a positive effect on food security. In about one third of the relationships there was no effect of agricultural diversity on food security, or the results were mixed. These numbers hold for the availability, access and utilisation dimensions of food security and at individual, household and farm scales, but the number of studies was too small to draw robust conclusions on the stability dimension and at global scale. Diversity can be an important driver of food security, but the magnitude of the contribution depends on the broader socio-economic and biophysical characteristics of the local farming system.

Sewando (2022) considered the efficacy of risk-reducing diversification portfolio strategies among agro-pastoralists in semi-arid areas. Agro-pastoralists in the tropical semi-arid dryland areas of Sub-Saharan Africa (SSA) are significantly affected by climate change and variability. Agro-pastoral families are coping with production-related climatic risks through livelihood diversification to ensure food security. Data were collected from a sample of 411 agro-pastoralists across five districts in the semi-arid northern and central regions of Tanzania through a survey conducted between November 2017 and July 2018. Secondary data regarding crop yields and livestock populations for eight years from 2009 to 2017 were collected from the National Bureau of Statistics and the respective District offices. Results show that about three-quarters of the agro-pastoralists managed diversified crop and livestock portfolios with two or more crops and animal species. However, simulated crop yields reveal positive correlations. Construction of integrated portfolios that generate good returns at a modest risk can be achieved through strategic choices between high-return, high-risk, and low-return, low-risk crop and livestock activities. Thus, the paper recommends costly long-term breeding and genotype improvement programs, strategically changing the make-up of the current crop and livestock portfolios, which appear to be an affordable and tailored solution for building risk resilience among agro-pastoral communities in the drylands.

Van Etten (2019) considers agricultural diversification as a risk management strategy with the

minimum regret model. The minimum regret model helps to fill this gap. It provides a simple, transparent calculation procedure that can be executed with existing spreadsheet software. Regret is an important heuristic in the behavioural sciences and regret-based models are used in finance. The paper presents the model with a numerical example. It also presents a framework to compare minimum regret portfolios with two limit cases (maximum utility and minimax regret). A case study illustrates the use of the model and the comparative framework.

Roosta et al. (2009) carried out to investigate factors affecting the capability of farmers in risk management. The statistical population consisted of 19536 wheat farmers from Khorasan-E-Razavi Province, Iran, who had been cultivating wheat during the farming year 2005- 2006 under the supervision of wheat experts. A stratified random sampling technique was employed, and several 400 farmers constituted the sample size of the study. The reliability and validity of the tools employed in the study were confirmed through pilot study and expert judgment. The results indicated that the most threatening risks in wheat production were either natural or of economic nature and the most important strategies taken to confront them were either technological or financial ones. Correlational analysis revealed that there were significant relationships between farmers' capabilities in risk management and their educational standing, their attitude towards risk, crop yield per unit of land, level of land under wheat cultivation, the total area of the cropping land, wheat marketing value, frequency and extent of consultation with agricultural experts and TV programs.

3. Methodology

In order to gauge the impact of hot money on capital and real estate market, unrestricted multivariate vector autoregressive (VAR) model is used. The model holds various advantages over single equation regression. The single-equation regression model only finds the association of economic variable but not the causes of variations. VAR model appends the multi period dynamics to the analysis by permitting both lagged and instantaneous effect of all economic variables. In contrast to estimating each regression independently it's better to employ VAR to estimate individual regression with in a system where all economic variables are endogenously resolute. However, it is

difficult to interpret the VAR coefficients; therefore we use Impulse Response Function (IRF) and Variance Decomposition analysis (VDC). The basic model equation setup is explained in equation (1).

$$\begin{bmatrix} X1(t) \\ \cdot \\ \cdot \\ X5(t) \end{bmatrix} = \begin{bmatrix} a11(L) & \dots & \dots & a15(L) \\ \cdot & \cdot & \cdot & \cdot \\ a51(L) & \dots & \dots & a55(L) \end{bmatrix} \times \begin{bmatrix} X1(t) \\ \cdot \\ \cdot \\ X5(t) \end{bmatrix} + \begin{bmatrix} \epsilon1(t) \\ \cdot \\ \cdot \\ \epsilon5(t) \end{bmatrix} \tag{1}$$

In the model [X1 (t) X5 (t)] represents the vector of economic variables. It contains (aij L) 5x5 matrix of polynomials in the lag operator. In model [ε1 (t) ε5 (t)] is vector of corresponding innovation processes with non-diagonal variance-covariance matrix of σ2Ω and a mean zero. The model contains seven variables and each endogenous variable depends on its own lagged values.

Question: What's the effect of production diversity effect on real and nomial income in Zanjan?

4. Results and Discussion

4.1. Data Description

The income risk associated with five crops (wheat, lentil, colza, potato, and tomato) has been estimated (see Figure 1) using the disparity between the Hodrick-Prescott and the generated income in two nominal and foxed modes. An increase in negative figures signifies a heightened level of risk. From 1991-1992 to 1993-1994, the income risk experienced both nominal and real shocks, as depicted in the graph. A positive shock signifies a diminished risk of income risk; however, following 1994-1995, there has been a decline in this trend. A negative income risk value signifies an exceptionally high degree of risk.

Subsequently, the crop diversity indicator for the five crops (wheat, colza, lentil, tomato, and potato) was computed from 1990 to 2022. Figure 2 displays the results. The year 2001-2002 exhibits the highest crop diversity indicator among the five crops, at 75%, as illustrated in Figure 2. This illustrates that a cultivation monopoly is established when the five crops are cultivated concurrently. However, the crop

diversity indicator was 28% between 2000 and 2001, indicating that crop diversity can be achieved by cultivating five crops simultaneously. Based on the mean crop diversity indicator across all harvesting years, which is 59%, it can be concluded that the

figure representing the impact of crop diversity on five crops is acceptable and rational. Although the effect may not be considerable, it remains relatively significant.

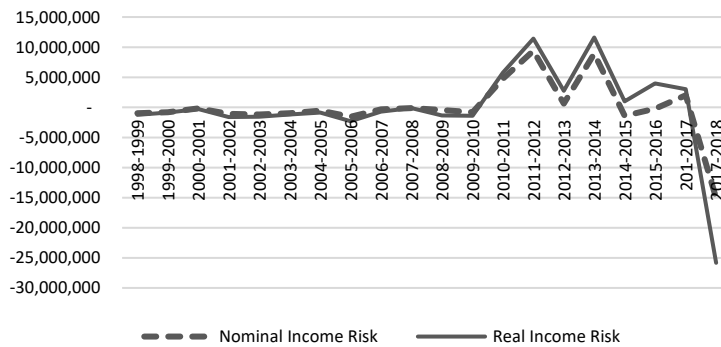


Figure 1. The Trend of Real and Current Income Risk Changes of Five Crops
Source: Ministry of Agriculture Jihad, 2023.

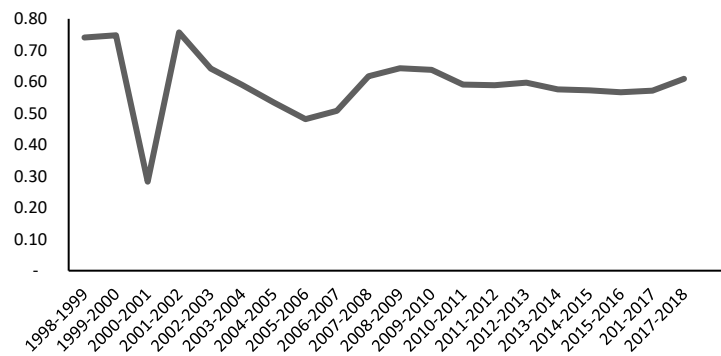


Figure 2. Crop Diversity Index for Selected Crops
Source: Ministry of Agriculture Jihad, 2023.

4.2. Unit Root Test

To study the impact of crop diversity on income, the stationarity of the data must be verified. First of all, to find the stationarity of data, the Augmented Dickey-Fuller (ADF) test is used which is the standard test for unit root. The estimated ADF statistics are given in Table 1, which presents the ADF test statistic value of all variables at the level and first difference. The acceptance or rejection of the null hypothesis depends upon the augmented Dickey-Fuller (ADF) statistic. If the ADF statistic is less than the tabulated values, then there is evidence of rejecting the hypothesis that there is a unit root at some level of confidence. The results indicate that all the variables have unit roots at the

level form but become stationary after taking the first difference. This means all series are integrated in the first order. The null hypothesis of the unit root is rejected when the entire variables are in their first difference form. The variable representing nominal income risk became stationary when the y-intercept differencing. Nevertheless, the KPSS test was utilized to assess the stationarity of the nominal income risk in light of the structural break in the variable. The aforementioned stationarity findings indicate that the applied VECM is the most suitable model for approximating the relationship between crop diversity and income risk variables. The results of the variables's stationarity are shown in Table 1. The

absolute value of the Dickey-Fuller criterion is greater than the critical absolute value of the same criterion for all variables; therefore, it has greater statistical

significance. In light of the unit-root test outcomes, one-time differencing was implemented as a solution to the variables' unit-root test problem.

Table 1. Variables Stationary Test

Variable	Stationarity requirement	Significance level	Test type	Prob.
Crop diversity	One time of differencing and y-intercept trend	1%	Dickey-Fuller	0.00
Nominal income risk	One time of differencing and y-intercept trend	1%	Dickey-Fuller	0.004
Real income risk	One time of differencing and y-intercept trend	5%	KPSS	0.00

Source: Research finding.

4.3. Cointegration Test

We follow the step-down procedure to identify the lag length criteria. The optimal lag length for JJ-cointegration is selected from optimal lag length selection criteria. The results of lag selection criteria indicates that standard indicator for selecting optimal lag order such as Final Prediction Error (FPE), Sequential Modified LR test statistic and Akaike Information Criteria (AIC) propose two lags criteria to

identify the number of co-integrating vectors the equation. Following, the approach proposed by Johansen (1987) and Johansen and Juselius (1990) the cointegration test uses two statistics to evaluate the number of co-integrating vectors. The two statistics include maximum Eigen value and trace statistics to determine the long run association between the variables.

Table 2: JJ-cointegration Results

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace value	2	2	1	1	1
Max-Eigen value	1	1	1	1	1
Critical values based on MacKinnon, Haug, & Michelis (1999).					
Selected (0.05 level*) Number of Co-integrating Relations by Model.					

4.4. VAR Model

After execution of unrestricted VAR, we can determine the time path effects of various endogenous shocks in the model. IRF determines the path of different economic variables when they return back to their equilibrium position after injecting the shock to the system. We use the Generalized Impulse Response Functions (GIRF) introduced by Pesaran and Shin (1998), creating a set of innovations that are not dependent on VAR ordering. The results in figure 1

show that one standard deviation shock in crop diversity index has a positive impact on real and nominal income.

The results of VDC of real income index reveal that none of the variable in short run significantly explains the change in the index. In the long run almost 16 % of change in real income is explained by crop diversity index. The results confirm our previous findings that support the significant role of crop diversity in real and nominal income.

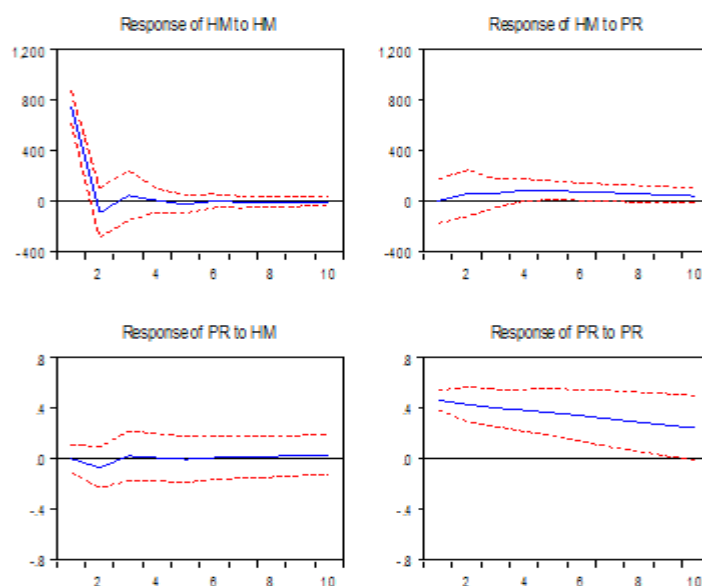


Fig 1. Impulse Response Functions

Period	S.E	HM	RP	SD
1	1.241	100.000	0.000	0.000
2	2.155	97.164	0.278	1.691
3	2.893	95.881	1.591	1.692
4	3.468	93.908	3.758	1.276
5	3.936	91.978	5.652	1.039
6	4.328	89.446	7.588	1.317
7	4.669	86.218	9.559	2.263
8	4.979	82.270	11.582	3.885
9	5.276	77.688	13.680	6.086
10	5.570	72.663	15.833	8.704

5. Conclusion

This paper aims to investigate production diversity as an economic risk management strategy. The present study spanned the years 1990 to 2022. The assessment of the degree to which crop diversity mitigates risk was conducted utilizing the Herfindahl index. The vector autoregression (VAR) was utilized to estimate the effect of crop diversity on two modes of risk to farmer income. As expounded upon in the results section, a correlation can be observed between crop diversity and reduced income risk over an extended period. The integration of a wide range of crops has effectively mitigated the income risk faced by producers in Zanzan Province. Thus, it is recommended that when formulating support policies

and optimal agricultural models, crop diversity be given particular consideration. The implementation of support policies that aim to assist a specific subset of farmers in their crop cultivation is an inappropriate alternative that exposes them to higher income risk. The results obtained from this study with research literature and studies of Hun and Um (2024), Sewando (2022), Van Etten (2019) has been matched.

As indicated by the IRF, approximately four-time cycles are required to balance the emergence of short-term shocks in the nominal income of producers. Real income-related shocks require three-time cycles to achieve a proportionate impact. Therefore, policymakers must take the initiative to facilitate diversity support policies to avert financial disruptions.

Meanwhile, reparative policies, such as insurance instruments, must be devised in the event of a shock, so that the impact can be recouped within a four-year timeframe. Small farmers, who depend on farming as their primary source of income and food provision, are particularly susceptible to adverse income shocks. However, this does not mean that large-scale farmers are impervious to income risks and shocks; in fact, they face a more severe hazard when confronted with an income shock. Consequently, risk management techniques must be implemented across the entire agricultural sector. Management strategies designed to mitigate income shocks may seem inconsequential at initial examination; however, they are of the utmost importance, given that any action taken can have repercussions.

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