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Social Overhead Capital and Output Nexus in Nepal: A Toda-Yamamoto Causality Analysis

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Abstract

Social overhead capital (SOC) is complementary to increasing productivity, particularly when the economy is also experiencing technological progress, thus spurring economies of scale and spillover effects. In its absence, the objective of developing nations to increase national output may be difficult to achieve. Such logjams are also found in Nepal. The objective of the study is to explore and evaluate the causal relationship between SOC and national output using VAR $(k + d_{max})$ *based on the Toda-Yamamoto Granger no-causality test. The study uses the time series data of 36 years from 1986 to 2021. Nominal gross domestic product (NGDP) is the dependent variable used to represent national output. Similarly, energy, road, telephone, vehicle, irrigation, gross fixed capital formation, health, and student enrollment in higher education are the independent variables used to represent SOC. The study found that roads, telephones, vehicles, and irrigation cause the NGDP, whereas overall SOC variables also caused the NGDP at a one percent significance level. It is also found that NGDP causes the energy, telephone, and enrollment of students in higher education. The study concluded that there is a significant causal nexus between SOC and NGDP directly or indirectly. The study underscores the vital need for the government of Nepal and policymakers to take measures to increase the national output and productivity. This means significantly strengthening key sectors like energy, infrastructure, healthcare, higher education enrollment and promoting fixed capital formation.*

Keywords: *Social overhead capital, Output, Causality, Toda-Yamamoto, VAR.*
JEL Classification: *H54, E01, C32, C51.*

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Introduction

Paul Rosenstein Rodan, Ragnar Nurkse, and Albert Hirschman are the chief development economists who advocate 'Infrastructure' as an umbrella that covers a variety of activities known as social overhead capital (SOC). SOC includes roads, schools, hospitals, and public parks (Black et al., 2012). Moreover, SOC consists of roads, bridges, public mass transportation systems, water and sanitation systems, electricity and other public utilities, and communications and postal services (Uzawa, 1998). Both terms refer to activities that share technological characteristics (i.e. economies of scale) and economic characteristics (i.e. spillovers) from users to non-users, even though neither is clearly defined (World Bank, 1994). SOC has multifaceted effects on economic growth. It is the source of external economies. On the one hand, SOC serves as an input for economic activity. On the other, it acts as a catalyst for capital formation that increases production capacity. Tools or material goods that increase our capacity or perform tasks for us are referred to as capital in economics (Weil, 2016). Thus, the utilization of capital is necessary for almost all employment. For most tasks, workers with more or better capital can produce a greater output.

Mechanics of human capital is the source of wealth for nations (Schultz, 1961; Romar, 1986; Lucas, 1988). Capital–output nexus is vital to the economic growth of nations (Harrod, 1939; Domar, 1947; Solow, 1956) that explained from different perspectives. Thus, economics and SOC are the backbone of the economic output via distinct direct and indirect channels. Economic infrastructure generally refers to the physical, economic, social, and human capital that can turn all resources into a productive channel.

Quantity and quality aspects of SOC impede the economic progress and growth of the nations. The distribution of services from different SOC components and the structure of SOC are both crucial for sustainable economic development (Uzawa, 1988). The quality of SOC influences an ability of nation to diversify its economy, increase trade, manage population growth, combat poverty, and improve environmental conditions (World Bank, 1994). In addition, it also emphasizes that only when infrastructure efficiently addresses these demand, it significantly promotes environmental sustainability, foster economic growth, and contributes to poverty reduction. Essentially, effectiveness of infrastructure lies in its alignment with the real needs of society ensuring both economic and social benefits. Increases in SOC stock have a favorable impact on changes in productivity of total factors in the service and manufacturing sectors in Korean economy (Yang & Adams, 1995).

Economic growth and social progress depend on the presence of high-quality and long-lasting physical infrastructure. The basis of economic growth is the expansion of social infrastructure, its services and the availability of them to all citizens. Government spending is rising in the areas of target group improvement, drinking water, sanitation, health, and education in Nepal (MoF, 2021). Infrastructure deficiencies provide a serious obstacle to the objectives of the short and long-term development of Nepal. Nepal must invest 8 to 12 percent of its GDP until 2020 to improve its infrastructure to a sufficient level (Dixit, 2017). The government has gradually increased its budget and spending to fulfill these escalating financial needs. The historical average growth of Nepal i.e. 4.9 percent might tempt a focus on speeding things up. But mere output expansion won't suffice. The World Bank warns of hidden threats to long-term prosperity. Sustainability and inclusivity are at stake, demanding Nepal tackle deeper challenges beyond just pushing for a growth sprint. This future-focused approach prioritizes a more robust and equitable development path for the nation (World Bank, 2022).

Research Problem

Most developing nations fall into the trap of inadequate physical and social infrastructure, resulting in poor economic growth. In reality, at very low-income levels, a vicious cycle may begin whereby low income causes poor investments in infrastructure, plants, equipment, and health care, which in turn causes low productivity and economic stagnation (Todaro & Smith, 2012). This circular and cumulative causation is the economic backwardness of developing nations (Myrdal, 1968). However, the fundamental facilities in the production process that could speed up economic growth are energy, irrigation, drinking water and sanitation, health, education, and innovation. SOC is gradually increasing, but its impact on production, productivity, and sustainable economic growth is skeptical in Nepal. Therefore, looking into whether ongoing SOC is built up on the right track is crucial. On the premise of this, the study tries to provide an answer to the given research question: Is there any causal nexus between SOC and the economic output of Nepal?

Research Objectives

Investment in SOC stimulates economic growth by enhancing productivity, reducing poverty, fostering human capital development, attracting investments, and boosting national output. With this notion of understanding, the study is intended to explore and evaluate the causal nexus between SOC and national output of Nepal.

Review of Literature

Many development economists promoted a theoretical nexus between SCO and economic output / growth. Arrow and Kurz (1970) have initiated to explain the theoretical connection between public investments (capital) and economic growth. Rostow (1960) has stated that the foundation of self-sustaining economic growth requires the accumulation of SOC. Hirschman (1958) contends that unbalancing the economy is the only way to achieve development. This is made possible by investing in either indirectly profitable activities or in SOC. The development calls for the implementation of numerous initiatives that positively impact the flow of money across many sectors, including agriculture, industry, transportation, power, public administration, education, health, and urban development among others. Therefore, investment in SOC is the most crucial component of economic development. Nurkse (1953) outlined the beneficial relationship between physical capital and economic growth.

Indivisibility and externalities on the supply side are most prominently manifested in SOC. With lengthy gestation times and delayed yields, its services are indirectly productive. As its most important product, it offers investment opportunities created in other industries. The SOC comprises a wide range of basic infrastructure industries like irrigation, energy, transport, communication, etc., which is directly related to the productive investment that can begin to yield faster returns (Rosenstein-Rodan, 1961). The research on endogenous growth demonstrates that an increase in public capital stock can boost the steady-state growth rate of output per capita with long-term growth implications. It also demonstrates that raising public capital stock can improve the steady-state growth rate of output per capita with long-term growth effects (Barro, 1990; Barro & Sala-i-Martin, 1992).

Many empirical studies have found a causal link between SOC and economic growth. The build-up of financing SOC can produce external economies and enhance the economy's productive capacity. Mobilizing the economic resources and output through which the national output will be promoted can be fruitful. The various types of SOC like road improvements (Bryan et al., 1997); energy consumption (Belke et al., 2011); transportation networks (Banerjee et al., 2020); transportation infrastructure (Mohmand, et al., 2017); telephone (Hardy, 1980); telecommunication as mainline tele density (Chakraborty & Nandi, 2011); gross fixed capital formation and enrollment in higher education health (Bloom et al., 2004); financial sector development and financial inclusion (Ahmed & Ansari, 1998; Gajurel, 2022) are positively and significantly connected with national output and economic growth.

Bashir (2013) examined the effects of SOC on economic output by considering the effects of transportation, communication, and education. The results showed that SOC and economic output have a long-term link. Additionally, the study found that the long-term economic production is being increased by its roads, telephone lines, and transmission hours of radio, educational expenditures, and higher education enrollment at the university level in Pakistan. On the other hand, in the long run, the number of post offices, the number of kilometers of railway tracks, and the number of kilometers flown by revenue from international airlines are negatively connected to economic activity.

Dhungel (2020) has evaluated the association between the infrastructure development and economic growth of Nepal by using time series data from 1994 to 2018 and an error correction model. The study concluded that the economic growth of Nepal is significantly impacted by infrastructure development by measuring the length of roads, economically active population, enrollment in tertiary education, and gross capital formation.

Srinivasu and Rao (2013) have established a significant relationship between infrastructure development and economic growth by using both growth theories and empirical data. They further explained that socio-economic overheads play a critical role in facilitating economic growth, reducing income inequality, poverty, and deprivation. So, it is important to invest in infrastructure development in the areas of irrigation, education, health, transportation, communication, hydroelectric works, watersheds, warehousing and markets, family welfare, research, and training. All of which play a significant role in the development, process by raising productivity of input factors.

Chakamera and Alagidede (2018) have investigated the growth effects of stock and quality of infrastructure in Sub-Saharan Africa. They found evidence for a unidirectional causality between combined infrastructure and growth, thereby providing substantial support for a positive impact of infrastructure development on economic growth.

Research Gap

There are only limited empirical studies on SOC and economic growth. The given set of literature review exhibits the significant effects of SOC on economic growth and development. The extensive literature underscores the pivotal role of SOC in economic growth across diverse contexts like Pakistan, Nepal, and Sub-Saharan Africa. However, notable research gaps persist. Firstly, while studies have delved into specific contexts, a comprehensive cross-country comparative analysis remains scarce, hindering a broader understanding of SOC's varied impacts across different economic and social landscapes. Secondly, the focus has primarily been on the quantitative aspects of SOC, such as its expansion in sectors like transportation and education. However, there is a discernible gap in exploring the qualitative dimensions—how the efficiency or quality of infrastructure influences economic outcomes. Additionally, although empirical evidence highlights a link between SOC and economic growth, in-depth examinations of underlying causal mechanisms and temporal dynamics are limited. Addressing these gaps would offer a more nuanced understanding of SOC's multifaceted contributions to economic development.

Methodology and Data

Nature and Sources of Data

The study used secondary data covering 36 annual observations from 1986 to 2021 (Appendix-I). The data set encompasses the recent economic phase of the economy of Nepal, characterized by its transition towards economic liberalization. The economic liberalization of Nepal fosters foreign direct investment (FDI), which is anticipated to influence GDP growth and bolster export trade positively (Bista, 2017). During this period, there has been a substantial surge in investment in SOC, warranting an exploration to establish its causal relationships with national output. To investigate the causal linkage between SOC and national output, nominal GDP is the dependent variable used as a proxy variable for national output. Moreover, energy, road, telephone, vehicle, irrigation, gross fixed capital formation, health, and enrollment of higher education students are proxy variables for SOC. To explain the elasticity of SOC variables to nominal GDP, a necessary logarithmic transformation has been performed (Appendix-II). The measurement of such variables and sources has been displayed in Table 1.

Table 1: Description of Variable of Interest

Proxies	Details	Measurements	Sources
NGDP	Nominal gross domestic product	NRs. in millions	NRB (2022)
Enrg	Total energy consumption	Oil in thousand tons	NRB (2022)
Road	Extension of road facilities	Kilometer	NRB (2022)
Tele	Fixed telephone subscriptions	Number	WDI (2022)
Vehl	Vehicles registered excluding two-wheelers	Number	NRB (2022)
Irig	Extension of additional irrigation facilities	Hectare	NRB (2022)
GFCF	Gross fixed capital formation (Current)	Rupees in millions	WDI (2022)
Helt	Total health institutions	Number	NRB (2022)
SEHE	Students enrollment in higher education	Number	NRB (2022)

Note. NRB, 2022; WDI, 2022.

Table 1 shows the description of variables used under study. The data were obtained from the database on the Nepalese economy of NRB and WDI (Appendix-I) World Bank data portal. Thus, all the variables regarding physical and human capital under the study are conceptually considered and accounted for some empirical evidence (Cootner, 1963; Ogawa, 1976; Hayami, 2009; Bashir, 2013).

Model Specification

The study explains the causal relationship between SOC and national output using quantitative techniques and an econometric model. The targeted national output function is expressed as follows:

$$NGDP = f(Enrg, Road, Tele, Vehl, Irig, GFCF, Helt, SEHE)$$

Taking natural log on both sides, the functional equation becomes as following -

$$lnNGDP = f(lnEnrg, lnRoad, lnTele, lnVehl, lnIrig, lnGFCF, lnHelt, lnSEHE)$$

The study applied a vector auto-regression (VAR) for causality test propounded by Toda and Yamamoto (1995). Before performing it, the unit root test and optimal selection were performed. Toda-Yamamoto causality is an augmented VAR ($k + d_{max}$) framework where 'k' is the optimal lag and d_{max} is the maximum order of integration. Toda and Yamamoto (1995) state that since the conventional asymptotic theory is true, the study employed a typical lag selection approach to a potentially co-integrated or integrated VAR. Once a lag length 'k' has been established, the study estimates a $(k + d_{max})^{th}$ order VAR where d_{max} is the highest order of integration. The study believes that it could occur throughout the procedure. The Toda-Yamamoto (1995) causality test with a Wald test system is estimated as follows (Adriana, 2014).

$$Y_t = \alpha_0 + \sum ki=1\ \beta 1iYt\text{-}i + \sum k+di=k+1\ \beta 2iYt\text{-}i + \sum ki=1\ \gamma 1iXt\text{-}i + \sum k+di=k+1\ \gamma 2iXt\text{-}i + \varepsilon_{1t}$$

$$\text{and, } X_t = \delta_0 + \sum ki=1\ \zeta 1iXt\text{-}i + \sum k+di=k+1\ \zeta 2iXt\text{-}i + \sum ki=1\ \eta 1iYt\text{-}i + \sum k+di=k+1\ \eta 2iYt\text{-}i + \varepsilon_{2t}$$

Concerning the study, $Y_t = lnNGDP_t$, $X_t = SOC_t = (lnEnrg_t, lnRoad_t, lnTele_t, lnVehl, lnIrig_t, lnGFCF_t, lnHelt_t, lnSEHE_t)$ and ε_{1t}, ε_{2t} refer to the residuals of this model. Based on the χ^2 statistics using the modified Wald test procedure, the null hypotheses for bidirectional causality between lnNGDP and SOC variables are tested.

$$H_0\text{: } lnSOC_t \text{ does not cause } lnNGDP_t \Rightarrow \gamma_{1i} = 0, i = 1, 2, \ldots, k.$$

$$\text{and} \quad H_0\text{: } lnNGDP_t \text{ does not cause } lnSOC_t \Rightarrow \eta_{1i} = 0, i = 1, 2, \ldots, k.$$

The Toda-Yamamoto causality test can be applied to level VARs regardless of the variables' integration status. Thus, non-stationary series with optimal lag and maximum order of integration can be employed to determine the causality. They argued that the commonly used F-statistic for Granger causality might not be valid when dealing with integrated or co-integrated time series data (Adriana, 2014). Furthermore, it is presumed that the order of integration (d_{max}) does not surpass the actual lag length (k) of the model allowing for testing linear or non-linear restrictions on the initial 'k' coefficient matrices through standard asymptotic theory. Conversely, the challenge with the model lies in the risk of overfitting the VAR. If the VAR comprises numerous variables with a true lag length of one, the inefficiency introduced by adding just one extra lag could be substantial. However, in scenarios where the VAR involves fewer variables but longer lag lengths, typically encountered in practical settings, and the inefficiency resulting from adding a few more lags might be comparatively small (Toda & Yamamoto, 1995).

Empirical Results and Analysis

After a descriptive summary, the maximum order of integration and optimum lag must be estimated to employ the Toda-Yamamoto causality. The unit root test and VAR-based lag length criteria were used to determine the order of integration and optimal lag. Toda-Yamamoto causality is then probed using the VAR ($k+d_{max}$) Wald process to look into the nexus between SOC and the national output of Nepal.

Descriptive Summary

The summary statistics include each variable's mean, median, standard deviation, kurtosis, skewness, minimum, and maximum. These statistics offer insights into the central tendency, dispersion, shape of the distribution, and range of values for each variable.

Table 2: Descriptive Summary of the Variables

Variables	lnNGDP	lnEnrg	lnRoad	lnTele	lnVehl	lnIrig	lnGFCF	lnHelt	lnSEHE
Mean	13.230	9.046	9.655	12.515	9.093	10.100	11.730	8.090	12.152
Median	13.150	9.055	9.745	12.885	8.918	10.207	11.547	8.352	11.940
St. Dev.	1.298	0.295	0.530	1.176	0.903	0.567	1.455	0.590	0.668
Kurtosis	- 1.091	- 0.744	- 1.011	- 1.108	- 0.812	3.059	- 1.040	- 0.102	- 0.859
Skewness	- 0.036	0.239	- 0.320	- 0.630	0.291	- 1.533	0.091	- 1.116	0.470
Minimum	10.928	8.554	8.706	10.166	7.538	8.217	9.223	6.889	10.903
Maximum	15.269	9.611	10.426	13.666	10.729	10.884	14.082	8.931	13.425

Source: Author's calculation, 2022.

Determination of Maximum Order of Integration

To estimate the maximum order of integration (d_{max}), the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were used. The ADF test for the null hypothesis ($\rho = 1$) that a series of variables (y_t) has a unit root can be run using the following equation:

$$\Delta y_t = \beta_0 + \beta_1 t + \rho y_{t-1} + \gamma_1 \Delta y_{t-1} + \gamma_2 \Delta y_{t-2} + \ldots.. + \gamma_i \Delta y_{t-i} + \varepsilon_t$$

With deterministic term, $\Delta y_t = \beta' D_t + \rho y_{t-1} + \sum \text{ki=1 } \gamma_i y_{t-i} + \varepsilon_t$

Additionally, using the same premise, the PP test for series stationarity with recession: $\Delta Y_t = \beta' D_t + \rho Y_{t-1} + \varepsilon_t$

Maximum order of integration is inevitable for the Toda-Yamamoto causality test. The estimated results of the ADF and PP unit root test of each variable of interest with order of integration are presented in Table 3.

Table 3: Results of Order of Integration

Variables	At Level		First difference		Second Difference		Integration
	C	C & T	C	C & T	C	C & T	
Phillips-Perron (PP) tests							
lnNGDP	- 1.41	- 1.98	- 3.92***	- 4.10**	…	…	I(1)
lnEnrg	0.89	- 2.14	- 6.86***	- 7.42***	…	…	I(1)
lnRoad	- 1.61	- 1.47	- 5.82***	- 6.11***	…	…	I(1)
lnTele	- 2.96**	2.13	- 1.08	- 2.78	- 6.68***	- 6.70***	I(0), I(2)
lnVehl	- 1.08	- 3.85**	- 13.46***	- 12.31***	…	…	I(0), I(1)
lnIrig	- 3.72***	- 3.93**	…	…	…	…	I(0)
lnGFCF	-0.80	- 1.79	- 4.13***	- 4.08**	…	…	I(1
lnHelt	- 1.51	- 1.64	- 2.50	- 2.51	- 3.90***	- 3.65**	I(2)
lnSEHE	- 1.18	- 2.79	- 8.51***	- 9.34***			I(1)
Augmented Dickey Fuller (ADF) tests							
lnNGDP	- 1.75	- 2.37	- 3.92***	- 4.10**	…	…	I(1)
lnEnrg	0.19	2.14	62***	5.95***	…	…	I(1)
lnRoad	- 1.49	- 1.48	- 5.82***	- 6.07***	…	…	I(1)
lnTele	- 2.06	2.13	- 1.29	- 2.79	- 6.69***	- 6.69***	I(2)
lnVehl	- 1.39	- 3.86**	- 7.96***	- 7.88***	…	…	I(0), I(1)
lnIrig	- 4.62***	- 5.27***	…	…	…	…	I(0)
lnGFCF	- 0.80	- 2.10	- 4.18***	- 4.13**	…	…	I(1)
lnHelt	- 2.40	- 2.48	- 2.29	- 2.29	- 4.88***	- 4.72***	I(2)
lnSEHS	- 1.27	- 2.70	- 6.18***	- 6.08***	…	…	I(1)

Source: Author's calculation, 2022.

*Notes:**Significant at the 10%; **Significant at the 5%; ***Significant at the 1%. C = constant; C & T = Constant & Trend.

Table 3 presents the results of Phillips-Perron (PP) test that indicates the order of integration for various variables. Variables like lnNGDP, lnEnrg, lnRoad, lnVehl, lnGFCF, lnHelt, and lnSEHE are found to be integrated of order one I(1), suggesting they are stationary after first differencing. However, lnTele shows a mixed order of integration [I(0), I(2)], indicating different stationary properties across different differencing levels. The table also illustrates the results of the Augmented Dickey-Fuller (ADF) test for various variables. Variables like lnNGDP, lnEnrg, lnRoad, lnGFCF, and lnSEHS exhibit integration of order 1[I(1)], indicating stationary after the first differencing. However, lnTele displays a mixed order of integration [I (2)], suggesting different stationary across different differencing levels. Based on both criteria of the unit root test, the highest order of integration (d_{max}) is 2, which means that I(2). The Toda-Yamamoto causality test can also deal with the non-stationary data.

Determination of Optimal Lag (k)

The Toda-Yamamoto causality test is employed as an augmented VAR ($k+d_{max}$).

Thus, the optimal lag length (k) is crucial for this type of causality. There are several criteria like sequential modified LR test statistic (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan-Quinn information criterion (HQ) to choose the optimal lag. FPE and AIC are suggested to be superior to other criteria in the study of small samples (Lütkepohl, 1991). Table 4 displays the outcomes of the VAR delayed order selection criteria.

Table 4: VAR Lag Order Selection Criteria

Lag	LR	FPE	AIC	SC	HQ
0	NA	1.13e-13	- 4.2733	- 3.8693	- 4.1355
1	476.5704	3.69e-20	- 19.366	- 15.3254	- 17.9878
2	131.1990*	2.15e-21*	- 23.3476*	- 15.6709*	- 20.7296*

Source: Author's calculation, 2022.
Note. (*) implies selected lad order.

Table 4 reports the various selection criteria for the ideal lag length. An asterisk in the results indicates that lag length 2 is optimal with all criteria. Lower values of AIC, SC, and HQ often indicate a better-fitting lag order for the VAR model. Thus, it is best to use the VAR-based Toda-Yamamoto causality test with lag length 2, which does not exceed d_{max}.

Toda-Yamamoto Causality

The given analysis confirms that the maximum order of integration is 2 (d_{max} = 2) and the optimal lag length is 2 (k = 2). Now, the Toda-Yamamoto causality is performed with the VAR model at $k+d_{max}$ = 4 to examine the nexus between SOC and NGDP. The Wald statistics (χ^2) with the direction of causality are demonstrated in Table 5.

Table 5: Toda-Yamamoto Causality: VAR (k + d_{max}) Granger No-Causality

Variables	lnNGDP	lnEnrg	lnRoad	lnTele	lnVehl	lnIrig	lnGFCF	lnHelt	lnSEHE
lnNGDP	-	5.20***	3.13	4.82***	0.89	3.05	1.94	2.81	21.49*
lnEnrg	2.96	-	3.12	7.29**	0.75	0.09	1.19	0.57	0.64
lnRoad	5.00***	2.83	-	3.39	2.14	1.07	6.79**	2.05	20.80*
lnTele	10.18*	1.50	2.04	-	2.08	0.00	14.36*	4.40	15.52*
lnVehl	7.24**	2.99	0.02	4.87***	-	0.98	6.13**	0.76	27.38*
lnIrig	5.49***	2.46	1.00	4.18	2.47	-	6.25**	3.30	19.19*
lnGFCF	0.04	3.88	4.19	3.49	0.35	3.90	-	4.32	5.71***
lnHelt	4.21	3.02	4.29	0.76	3.73	1.26	1.42	-	15.84*
lnSEHE	1.37	7.34**	0.41	1.82	0.56	0.84	0.17	1.06	-
All	34.99*	48.92*	19.28	28.25**	13.21	17.14	48.73*	23.80***	277.98*

Source: Author's calculation, 2022.
Notes: *Significant at the 1%; **Significant at the 5%; ***Significant at the 10%.

Table 5 reports the Wald processed Toda-Yamamoto causality χ^2 statistics. The results show that lnRoad (at 10%), lnTele (at 1%), lnVehl (at 5%), and lnIrig (at 10%) significantly cause lnNGDP. The overall SOC variables also provide evidence of a causal nexus between SOC and NGDP (at 1%) significance level. These results are consistent with empirical evidence (Dash & Sahoo, 2010; Timilsina et al., 2021). Thus, the results reveal strong evidence of SOC and NGDP causal linkage in Nepal. The channel mechanism by which SOC influences national output is multifaceted. It operates by creating an enabling environment for economic endeavors, enhancing human and physical capital formation, mitigation of operational expenditures, facilitating connectivity and opening the market, size and scale economies, and the overall amplification of productivity and efficiency across diverse economic sectors. These collective improvements in infrastructure contribute significantly to the expansion of national output and consequent economic development.

In addition, lnNGDP also causes the lnEnrg (at 10%), lnTele (at 10%), and lnSEHE (at 1%) significantly consistency with Kumari and Sharma (2017) and Gherghina et al. (2018). It reveals that there is bi-dimensional causality between lnNGDP and SOC. The possible causes behind this causal connection may be that a higher NGDP often enables increased investment in infrastructure, education, healthcare, and innovation, boosting the development of both social and physical capital within an economy by enhancing resources and fostering technological advancements while also improving standards of living and strengthening societal networks.

Results also reveal that there is a bi-directional causal linkage between lnNGDP and lnTele. But, there is a unidirectional causality presence among the variables in the study like - lnRoad → lnNGDP, lnVehl → lnNGDP, lnIrig → lnNGDP, lnNGDP → lnSEHE, lnNGDP → lnEnrg, lnSEHE → lnEnrg, lnEnrg → lnTele, lnVehl → lnTele, lnRoad → lnGFCF, lnTele → lnGFCF, lnVehl → lnGFCF, lnIrig → lnGFCF, lnRoad → lnSEHE, lnTele → lnSEHE, lnVehl → lnSEHE, lnIrig → lnSEHE, lnGFCF → lnSEHE, and lnHelt → lnSEHE.

The Toda-Yamamoto causality also estimates that enrollment of students in higher education causes energy; energy and vehicle cause telephone; road, vehicle, telephone, and irrigation cause GFCF; NGDP, road, telephone, vehicle, irrigation, GFCF, and health cause enrollment of students in higher education. Thus, the overall findings reveal that there is a significant causal nexus between SOC and NGDP directly and indirectly.

Major Findings, Conclusion, and Implication

This study attempts to explore the causal nexus between SOC and Nepal's NGDP by using the Toda-Yamamoto Granger no-causality test. The Wald procedures of VAR ($k+d_{max} = 4$) were estimated to project the presumed nexus between SOC and national output. The Toda-Yamamoto causality reports that roads, telephones, vehicles, and irrigation cause the NGDP. Overall, SOC variables also cause the NGDP to be at a 1 percent level of significance. The results also display that NGDP and telephone have bi-directional causality. It is also found that NGDP causes energy, telephone, and enrollment of students in higher education. Most variables except energy have a causal linkage with the enrollment of students in higher education and thereby cause the NGDP. Thus, the education sector is crucial to enhancing Nepal's productivity and national output. Likewise, gross fixed capital formation will be beneficial to increase national output in Nepal.

The overall findings reveal a significant linkage like investments in education leading to increased energy demand and driving infrastructure development (vehicles, telephone). This expanded infrastructure, influenced by various elements, notably roads, vehicles, telephone, and irrigation, strongly contributes to economic growth through gross fixed capital formation (GFCF) ultimately boosting NGDP. This intricate relationship emphasizes the vital connection between social development and economic advancement. Thus, the overall findings conclude that there is a significant causal nexus between SOC and NGDP directly and indirectly. Most of the literature reviewed also supports the findings of the study.

Thus, the Toda-Yamamoto causality demonstrates that the SOC drives economic production and national output of Nepal. Major SOC variables are immediately influenced by national output, while others are indirectly affected. It is determined that SOC can raise national output and productivity of Nepal. Besides, national output also contributes to the SOC of Nepal. Thus, the study provides evidence for a causal nexus or linkage between SOC and national output of Nepal. Hence, to accelerate national output and productivity of Nepal, the government and policymakers should pay more attention to enhancing the energy, health, enrollment of students in higher education, and fixed capital formation sectors.

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Appendix I: Level Data of the Variables under Study

Years	NGDP (Rs. In Million)	Energy (in '000' Ton)	SEHE	Total Health Insts.	Extension of Road (in KM)	No. of Vehicles	Fixed Tele. Sub^n	Extension of Irrigation	GFCF
1986	55734.00	5189.00	54355.00	981.00	6039.00	2121.00	26000.00	27231.00	10124.00
1987	63864.00	5377.00	78490.00	1070.00	6306.00	1879.00	30404.00	36572.00	12459.00
1988	76906.00	5482.00	82967.00	1075.00	6611.00	2228.00	38000.00	34602.00	15321.00
1989	89270.00	5700.00	94662.00	1088.00	6611.00	3267.00	45457.00	53304.00	16176.00
1990	103416.00	5929.00	102200.00	1096.00	6706.00	2794.00	57320.00	25666.00	16671.00
1991	120370.00	6115.00	123462.00	1098.00	8328.00	4479.00	64894.00	22288.00	22780.00
1992	149487.00	6247.00	155649.00	1312.00	8851.00	4210.00	68886.00	33833.00	29277.00
1993	171474.00	6422.00	148374.00	1833.00	9293.00	4548.00	72683.00	30405.00	37278.00
1994	199272.00	6647.00	139916.00	2441.00	9664.00	6045.00	75637.00	33542.00	42032.00
1995	219175.00	6846.00	131574.00	3038.00	10724.00	5605.00	83713.00	25372.00	48370.00
1996	248913.00	6972.00	101092.00	3643.00	11237.00	9060.00	112645.00	48530.00	56081.00
1997	280513.00	7188.00	106887.00	4240.00	11714.00	4711.00	139989.00	32018.00	60794.00
1998	300845.00	7378.00	100390.00	4257.00	13223.00	6492.00	208387.00	21447.00	65375.00
1999	342036.00	7759.00	128314.00	4266.00	13709.00	4411.00	253035.00	49015.00	65269.00
2000	379488.00	7869.00	134837.00	4261.00	15308.00	5092.00	266890.00	35702.00	73324.00
2001	441519.00	8128.00	153935.00	4238.00	15702.00	7876.00	298062.00	29661.00	84750.00
2002	459442.55	8294.00	152691.00	4249.00	16834.00	7515.00	327673.00	17587.00	89889.00
2003	492230.78	8501.00	152522.00	4228.00	16947.00	4848.00	371816.00	11823.00	98073.00
2004	536749.05	8615.00	136000.00	4221.00	17182.00	9525.00	417944.00	12753.00	109181.00
2005	589411.67	8616.00	142877.00	4210.00	17279.00	7411.00	484640.00	11325.50	117539.00
2006	654084.13	8844.00	173175.00	4216.00	17433.00	9567.00	611544.00	18402.00	135532.00
2007	727826.97	8944.00	159497.00	4191.00	17782.00	6204.00	701126.00	26967.50	153337.00
2008	815658.20	9112.00	203529.00	4195.00	19147.00	6462.00	805061.00	16613.00	178446.00
2009	988271.53	9388.00	208956.00	4392.00	19758.00	12936.00	812615.00	25850.00	211039.00
2010	1192773.57	9876.00	243557.00	4392.00	21093.00	23730.00	841698.00	30718.00	264888.00
2011	1562680.98	10155.00	174117.00	4393.00	23209.00	20659.00	845542.00	35748.00	373938.79
2012	1758379.18	8820.00	436409.00	4393.00	24389.00	13299.00	831703.00	32565.00	421842.33
2013	1949294.82	10038.00	676892.00	4393.00	25265.00	17518.00	829097.00	19561.00	482065.12
2014	2232525.28	11232.00	480891.00	4485.00	26446.00	18349.00	837266.00	19310.00	563759.18
2015	2423638.48	11727.56	374647.00	4505.00	27496.00	23803.00	846940.00	18083.00	667804.68
2016	2608184.44	11767.69	441461.00	4599.00	28308.00	45667.00	858237.00	24291.00	748685.12
2017	3077144.92	12866.04	453092.00	4503.00	29117.00	41354.00	861299.00	41180.00	940850.49
2018	3455949.29	13483.90	486623.00	4513.00	30088.00	41437.00	799368.00	39669.00	1120863.89
2019	3858930.40	14014.13	538184.00	5717.00	32879.00	42575.00	762000.00	3705.00	1304902.17
2020	3888703.65	14464.05	546279.00	7154.00	33244.00	18603.00	726000.00	5569.00	1184857.69
2021	4277301.87	14927.49	556797.00	7566.00	33717.00	31957.00	563465.00	39601.00	1276857.15

Source: All the data obtained from NRB database (https://www.nrb.org.np/database-on-nepalese-economy) except fixed telephone subscriptions and gross fixed capital formation which is obtained from World Bank Data Bank, (https://databank.worldbank.org/source/world-development-indicators).

Appendix II: Log Data of the Variables under Study

Years	lnNGDP	lnEnrg	lnSEHE	lnHelt	lnRoad	lnVehl	lnTele	lnIrig	lnGFCF
1986	10.9283	8.5543	10.9033	6.8886	8.7060	7.6596	10.1659	10.2121	9.2227
1987	11.0645	8.5899	11.2707	6.9754	8.7493	7.5385	10.3223	10.5070	9.4302
1988	11.2503	8.6092	11.3262	6.9801	8.7965	7.7089	10.5453	10.4517	9.6370
1989	11.3994	8.6482	11.4581	6.9921	8.7965	8.0916	10.7245	10.8838	9.6913
1990	11.5465	8.6876	11.5347	6.9994	8.8108	7.9352	10.9564	10.1529	9.7214
1991	11.6983	8.7185	11.7237	7.0012	9.0274	8.4072	11.0805	10.0118	10.0336
1992	11.9150	8.7399	11.9554	7.1793	9.0883	8.3452	11.1402	10.4292	10.2846
1993	12.0522	8.7675	11.9075	7.5137	9.1370	8.4224	11.1939	10.3224	10.5262
1994	12.2024	8.8019	11.8488	7.8002	9.1762	8.7070	11.2337	10.4206	10.6462
1995	12.2976	8.8314	11.7873	8.0190	9.2802	8.6314	11.3351	10.1414	10.7866
1996	12.4249	8.8497	11.5238	8.2006	9.3270	9.1116	11.6320	10.7899	10.9346
1997	12.5444	8.8802	11.5795	8.3523	9.3685	8.4577	11.8493	10.3741	11.0152
1998	12.6144	8.9063	11.5168	8.3563	9.4897	8.7783	12.2472	9.9733	11.0879
1999	12.7427	8.9566	11.7622	8.3584	9.5258	8.3919	12.4413	10.7999	11.0863
2000	12.8466	8.9707	11.8118	8.3573	9.6361	8.5354	12.4946	10.4830	11.2026
2001	12.9980	9.0031	11.9443	8.3518	9.6615	8.9716	12.6051	10.2976	11.3475
2002	13.0378	9.0233	11.9362	8.3544	9.7312	8.9247	12.6998	9.7749	11.4063
2003	13.1067	9.0479	11.9351	8.3495	9.7378	8.4863	12.8262	9.3778	11.4935
2004	13.1933	9.0613	11.8204	8.3478	9.7516	9.1617	12.9431	9.4535	11.6008
2005	13.2869	9.0614	11.8697	8.3452	9.7572	8.9107	13.0912	9.3348	11.6745
2006	13.3910	9.0875	12.0621	8.3466	9.7661	9.1661	13.3237	9.8202	11.8170
2007	13.4978	9.0987	11.9798	8.3407	9.7859	8.7329	13.4604	10.2024	11.9404
2008	13.6118	9.1173	12.2236	8.3416	9.8599	8.7737	13.5987	9.7179	12.0920
2009	13.8037	9.1472	12.2499	8.3875	9.8913	9.4678	13.6080	10.1601	12.2598
2010	13.9918	9.1979	12.4031	8.3875	9.9567	10.0745	13.6432	10.3326	12.4871
2011	14.2619	9.2257	12.0675	8.3878	10.0523	9.9359	13.6477	10.4842	12.8318
2012	14.3799	9.0848	12.9863	8.3878	10.1019	9.4954	13.6312	10.3910	12.9524
2013	14.4830	9.2141	13.4253	8.3878	10.1372	9.7710	13.6281	9.8813	13.0858
2014	14.6186	9.3265	13.0834	8.4085	10.1829	9.8173	13.6379	9.8684	13.2424
2015	14.7008	9.3697	12.8337	8.4129	10.2218	10.0776	13.6494	9.8027	13.4118
2016	14.7742	9.3731	12.9978	8.4336	10.2509	10.7291	13.6626	10.0979	13.5261
2017	14.9395	9.4623	13.0239	8.4125	10.2791	10.6299	13.6662	10.6257	13.7545
2018	15.0556	9.5093	13.0952	8.4147	10.3119	10.6319	13.5916	10.5883	13.9296
2019	15.1659	9.5478	13.1960	8.6512	10.4006	10.6590	13.5437	8.2174	14.0816
2020	15.1736	9.5794	13.2109	8.8754	10.4116	9.8311	13.4953	8.6250	13.9851
2021	15.2688	9.6110	13.2300	8.9314	10.4258	10.3721	13.2419	10.5866	14.0599

Source: Author's calculation.