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PLS algorithm for estimating quality rural electricity on household income in Tanzania

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Abstract

Purpose – This paper aims at discussing the impact of quality electricity on household income (HI) in rural areas with complementarities and intermediary resources context.

Design/methodology/approach – Partial least square-structural equation modelling (PLS-SEM) was used to estimate complex variables of quality electricity (QEC), development assets (DEA) and individual motivation (IMO) on rural HI. Age, education and gender were treated as moderators of antecedents for HI whilst household strength (HS) was treated as a mediator.

Findings – The findings show that QEC is an important predictor for HI in rural areas. In similar vein, land, social network, financial and physical resources cannot be undermined in bringing HI on stage. Moreover, IMO is a best complementary for electricity to bear impact on income. In fact, income cannot be equated with one factor; hence, moderating roles of education and gender should be considered.

Research limitations/implications – The results are limited to QEC, IMO and DEA as key resources which are associated with HI.

Practical implications – The findings should be twinned with rural development policy. There must be a multi-dimensional approach in diversifying development resources to the rural people for aggregated benefits.

Social implications – The rural communities remain in dire need of electricity which is a precious resource for income generation. Electricity works better with other resources.

Originality/value – Previous scholars have inferred HI in relation to electricity. Income is a function of many resources. This study inculcated complementaries and intermediaries along QEC. Unique PLS-SEM was used in rethinking some of the rethinking of QEC–income relationships.

Keywords Rural electricity, Household income, Quality electricity, Income poverty, PLS-SEM

Paper type Research paper

1. Introduction

The effort for income poverty reduction is a global agenda rooted in Sustainable Development Goal One (SDG1) "ending extreme poverty in all forms". Whilst developing countries like Bangladesh, Haiti and Tanzania take diversified strategies for ending income poverty, the key focus has been placed on the rural electricity supply (Saing, 2017; Bosu *et al.*, 2017; Matinga and Annegarn, 2013). However, the strategy is seemingly hardly surprising (Lewis and Severnini, 2019), because it is thought to have a nexus with welfare improvement (Kumar and Rauniyar, 2018). Electricity supply also aims at serving about 1.2 billion people (17% of the global population) who lack access to modern energy (International Energy Agency, 2015); about 85% with no access to electricity are in Sub-Saharan Africa (SSA) and

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Southern Asia (SA). However, those with access (83% globally) are troubled by the intermittent supply of up to 20 h per month (Min *et al.*, 2017). This low-quality supply of electricity is, however, more pronounced in rural SSA and SA.

The paper validates an ongoing debate of the impact of electricity on income by answering the key questions: first, whether QEC (alone) intertwined with other resources (DEA like land and access to financial services and IMO such as desire for income) predict HI and second if complementarities and intermediaries have a positive effect in bringing rural HI on stage. HI includes the income of the household head and all people aged 18 years and above in the household (Guzman, 2018). Income is about financial and non-financial assets (Barker, 2010) which are proxy of many indicators like health, education, age, gender and time (Peters and Sievert, 2015; Barron and Torero, 2014). People in rural areas of SSA (41%) suffer from high levels of income poverty (World Bank, 2018). In Tanzania, particularly in the Kigoma region, about 48% live below the poverty line (Kilama, 2016). The scenario is rooted in persisting electricity poverty, nonworking policy, political structures, lack of markets for agricultural products and unequal access to available resources. With so many contributors to income poverty, electricity poverty is seemingly a great cause (Khandker *et al.*, 2009).

Electricity access is viewed as a remedy in reducing income poverty; nonetheless, it should not be regarded as the end in itself, but the means to stimulate small business, access to information and opening arrays of economic opportunities (Kooijman, 2008). For that, the paper argues that electricity should be studied in complement with other resources for robust inferences. Additionally, IMO as an intangible resource and HS (wealth background, experience and skills in resource mobilisation) should not be overlooked because income generation lies in the best decision and skills to capitalise on the readily available opportunities and resources. To that end, this paper is built on resources-based view (RBV) and PLS-SEM) to find out if the desired resources predict HI. The need to understand the impact of rural electricity on HI is a concern of development planners; in fact, it has been a subject of enquiry in economic literature (Sekantsi and Motlokoa, 2015). The focus on income is palatable because it is not the end, but the means to achieve other facets of development (Besley, 2007).

Bridge *et al.* (2016) argue that in developing countries, income is difficult to measure due to many economic activities taking place in informal markets. However, studying electricity versus income (Magnani and Vaona, 2016; Béguerie and Pallière, 2016; Lee *et al.*, 2016; Stern *et al.*, 2016) revealed mixed results. This is linked with first, negligible considerations on whether electricity was of a quality (reliability, voltage stability) to render effects and second, methodological approaches where various studies (Princewill *et al.*, 2019; Vaona and Magnani, 2014; Niu *et al.*, 2013; Akpan *et al.*, 2013; Lipscomb *et al.*, 2013) have modelled electricity as the sole predictor of income. This is contrary to Bastakoti (2003) who maintains that electricity with no complementary service will not create any necessary development impact. In the same vein, different analytical methods have been used to model income; for example, Khandker *et al.* (2009), Kumar and Rauniyar (2018) used propensity score matching (PSM); Akpan *et al.* (2013) and Lee *et al.* (2016a, b) used ordinal least squares (OLS) to deduce the positive impact of electricity on HI. For that, the results could hardly be dependable as van de Walle *et al.* (2015) explicated that with such models' impacts could be correlated with omitted variables; yet, there could be external effects.

In unceasing considerations of complementarities, Bastakoti (2003), Lenz *et al.* (2016) and Torero (2015) argued for the need to include such complementarities (education, roads, water and land) in the energy-income assessment. Thus, to shed light on the shadow, this paper considers QEC as a strategic resource of interest which has to be modelled along the tangible and intangible DEA (Figure 1). Besides, the inclusion of intermediaries like HS and interaction effects of age, gender and education is paramount for robustness of inference. The paper's approach is also supported by Akter *et al.* (2017) who suggested that "we live in a complex, multivariate world (and that) studying the impact of one or two variables in isolation, would

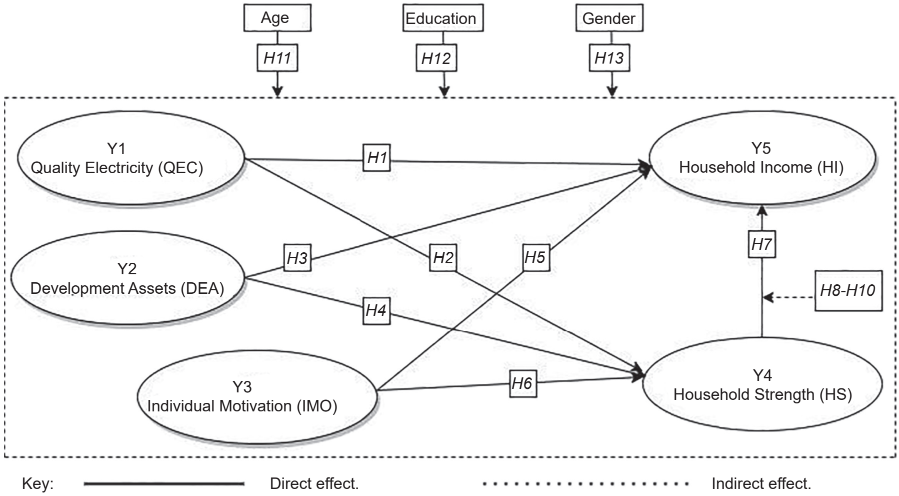
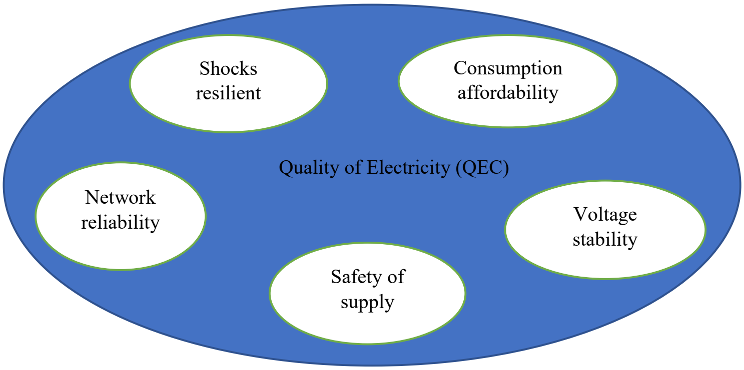


Figure 1.
Theoretical model

seem relatively artificial and inconsequential". For that, the income of the household if linked only with one variable (electricity) would result in shaky fallouts.

1.1 Resource-Based View
RBV was first propounded by Wernerfelt in 1984; ironically, most of Wernerfelt's arguments did not grow (Barney and Clark, 2007) until developed by Barney in 1991 (Montgomery, 1995). RBV determines strategic resources for an organisation's sustainable competitive advantage (SCA). In this paper, the household is viewed as the heterogeneous organisation which requires diverse resources (assets) and favourable conditions to accrue income for the reason that different types of resources have different effects and scale (Barney and Clark, 2007). The RBV assumes that to attain income goal, tangible and intangible internal resources must fully be used. The resources include physical, financial, human and household capital resources. Barney (1991) poses the assumptions for the resources that they must be valuable; to allow the household to accrue better income; rare amongst the households; imperfectly imitable meaning it cannot easily be replicated and finally be non-substitutable. Indeed, for theoretical model development as shown in Figure 1, intangible valuable resources like QEC and human behavioural assets such as IMO which is a driver of decision-making in income generation in the complex environment have been considered (Guay *et al.*, 2010). Nonetheless, it also leans on tangible DEA composed of land, financial, workforce and HS (DFID, 2000).

1.2 Theoretical model and hypotheses development
1.2.1 Quality electricity criteria for household income generation. QEC (Figure 2) has been equated with income growth at the household and national level (Kooijman, 2008). The impact of electricity on income has been a subject of debate from energy development economists (Pempetzoglou, 2014). Burlig and Preonas (2016) and Lee *et al.* (2016) report mixed results about electricity's impact on income. At the same, Economic Consulting Associates (2014) infers that there is little direct evidence of income being influenced by electricity. Nonetheless, at the national level, Shiu and Lam (2004) and Lee and Chang (2008) stated electricity to income [Gross Domestic Product (GDP)] causal flow whilst Kahsaia *et al.* (2011) and Ozturk (2010) found bidirectional flow between energy and income. Moreover, Lee (2006) reports



Source(s): Chatterton (2014), Bhatia and Angelou (2015)

Figure 2.
Quality of electricity

income-energy consumption causal, whereas Payne (2009), Huang *et al.* (2008) and Fatai *et al.* (2004) found no causal relationship. The mixed result is perhaps due to methodological approaches; for example, Kembo (2013) used scale measures to infer electricity to income effect and Lee and Chang (2008) used Granger causality, whilst Fatai *et al.* (2004) used Toda and Yamamoto test.

In their studies, Lipscomb *et al.* (2013) and Dinkelman (2011) argues that electricity influences women's income growth through employment and home-based business activities; although the wage increase was not clearly indicated (van de Walle *et al.*, 2015), there was evidence that electricity improves the income of women through business indicators. Whilst Iyke and Odhiambo (2012) infer distinct causal effect of electricity on the income of consumers; van de Walle *et al.* (2015) stated that connected and unconnected consumers can benefit through business opportunities that come along, for example, electrified markets. Besides, Khandker *et al.* (2009) and Lenz *et al.* (2016) advocated that electricity improves domestic expenditure, education and income through increased demand of service. However, in typical rural Africa, the evidence of impact remains weak (World Bank, 2018 in Lenz *et al.*, 2016), because micro-enterprises are affected by limited markets and intermittent power. The debate portrays mixed results on the electricity–income relationship. Again, this could be associated with the types of variables measured. For example, Lewis and Severnini (2019), Torero (2015), Barron and Torero (2014) and Nakata and Kanagawa (2008) inferred that electricity saves the time about nine hours per week (water pumping and washing) and let people engage in business and it improves health and education for more study hours which are long time proxy of income.

Lewis and Severnini (2019) indicated that with electricity, on-farm activities were improved through milking machines, production and income and saved milking time by 50%; more importantly, land value and housing quality increased given *ceteris paribus*. However, Peters and Sievert (2015) commented that electricity increases income by 34% for off-farm activities; this is cultivated by an increased business (Rud, 2012). On similar views, Akpan *et al.* (2013) stated that 16.2% more profit from business connected to electricity a phenomenon supported by Kembo (2013) and Lee *et al.* (2016a, b) that in rural Kenya, 53% of the business; cornmeal, barber shop, salon and small food stands had a better performance. QEC offers a flair for micro-business to enjoy an extension of working hours and reduction of operation cost, especially through milling machines. In fact, the continued mixed results of impact of electricity income of the household amongst many reasons are centred on less consideration of quality indicators of electricity (Figure 2) as ascribed by Stern *et al.* (2016)

and Akpan *et al.* (2013) that persisting reliability problem of electricity affects firms and income generation at all levels.

The question of power quality based on voltage stability, system shock resilience and safety of supply must be considered in qualifying electricity. Electricity with such qualities adds to HS and capability. Voltage stability enables all necessary appliances, such as ice boxes, bulbs, milling machines and television (TV) to operate properly. A power system which is resistant to shocks emanating from weather conditions and human activities usually energises the household. Whilst reliability is understood to be the ensured and continued supply of electricity, the household can benefit by reducing costs on backup devices and fuel, hence saving income in the expenditure basket. Further, for the household to feel secure, affordability of electricity consumption should be a priority; hence, households should not use more than 5% of their income on electricity (Bhatia and Angelou, 2015). Consequently, it is hypothesised as follows:

H1. QEC has a significant influence on HI.

H2. HS is significantly explained by QEC.

1.3 Development assets (DEA) and rural household income

In reality, there might be no single factor and asset to affect HI, but a combination of many not limited to land, financial, technology and human capital (DFID, 2000). For that, Torero (2015) and International Energy Agency (IEA) (2013) consider electricity as essential for development: though it adds to HS, it alone may not be able to create all conditions for economic and subsequent income to the rural poor. Thus, for vigorous inferences, incorporating various key resources along electricity may not be an option. For instance, in assessing the impact of electricity access on borrowers from commercial banks, Magnani and Vaona (2016) proposed some other related indicators, like availability of funds and unemployment insurance. This signifies that a single factor for some outputs is not guaranteed.

Matinga and Annegarn (2013) attested that electricity's impact on income was unclear (no business stemmed from electricity access, no extended business hours) and may not materialise because of the lack of complementary services and resources. Indeed, disregarding the rest of assets and factors in predicting HI, spurious and injurious results become so obvious. This is because rural households have for a long time benefited from other resources (land and livestock) even before the electricity connection. Consequently, for robust results and unlike previous studies (Princewill *et al.*, 2019; Palit and Bandyopadhyay, 2016; Burlig and Preonas, 2016; Bezerra *et al.*, 2017; Bosu *et al.*, 2017; Magnani and Vaona, 2016; Sekantsi and Motlokoa, 2015), this paper models QEC along the rest of DEA like land, technology and human workforce whilst assessing if resources availability predicts HS. Accordingly, it is hypothesised as follows:

H3. HI is significantly explained by DEA.

H4. DEA significantly influence HS.

1.4 Individual motivation (IMO) for household income

Motivation refers to the reasons underlying an individual's behaviour (Guay *et al.*, 2010); it is the attribute that pushes humans to do or not to do something and is a root for decision-making for a course. Motivation can be intrinsic if animated by personal satisfaction and enjoyment; thus, people seek achievement because they possess an effective desire; it is extrinsic if manifested from external pressures (Kaplan *et al.*, 2009). Motivation is, therefore, considered to be an intangible resource which makes up individual behaviour (pro-active behaviour), as it constitutes a significant force (Montgomery, 1995). When people are deprived of responsibilities, desires for recognition and acceptance they develop behaviour for income, either through micro-enterprises, saving and or purchases of assets. Udvari and Voszka (2018) have studied motivation's influence on student's expectation and decision and found its significant influence. However, the income of households in relation to electricity has always been assessed in the absence of motivation consideration. An organisation (household) having intrinsically and extrinsically motivated individuals is considered as having key strength, as it helps goal achievement at all levels. Thus, it is hypothesised as follows:

H5. HI is significantly explained by IMO.

H6. IMO has a significant influence on HS.

1.5 Household strength (HS) as a mediator

The strength of the household lies in its wealth accumulation background and resource mobilisation strategies (DFID, 2000). Strength is considered an important complementarity and should not be underrated in assessing income generation because having DEA is one thing and having the ability to capitalise on them is a different thing. For resources to yield better, complementarities should be called in the analyses (Lenz *et al.*, 2016). Thus, for similar views, Torero (2015) explained the importance of some complementarities and intermediaries such as education, roads, health, water supply and markets in assessing the impact of electricity on income. In unceasing recognition of intermediaries, Bridge *et al.* (2016) modelled electricity's ability to predict income through a simultaneous system of equations via three-stage least squares (3SLS). In fact, there was a direct and indirect impact through the intermediate effects of education and agriculture. Reliance on electricity, IM and DEA like land, technology and fiscal assets, in the absence of intermediaries could hardly offer assurance of improving HI through home-based business establishment; for that, the paper hypothesised as follows:

H7. HS significantly influence HI

H8. HS significantly mediates the relationship between QEC and HI.

H9. HS significantly mediates the relationship between DEA and HI.

H10. HS has significant mediation effects on the relationship between IMO and HI.

1.6 Age, education and gender as moderators

In this paper, age is the number of years a person has already lived (Sungiato, 2017). Human age is classified into four categories, as a child (0–12 years), adolescent (13–18 years), adult (19–59 years) and senior adult (60 years and above) (Nithyashri and Kulanthaivel, 2012). Based on energy and mobility capability (Tiruwa *et al.*, 2018), this paper classifies and models age as a categorical moderator where 18–50 years is active age, whilst 51 years and above is less active age. Speaking on that, age has been argued one of the key drivers of success in accruing income. It is associated with work energy, risk-taking, mobility and information processing which Walsh *et al.* (2008) argued that it deteriorates with age. Age is an important moderator in technology acceptance (Tiruwa *et al.*, 2018) whilst in business it is the best moderator for satisfaction and loyalty (Mithal and Kamakura, 2001). To the best knowledge of the present author, age has not been included in energy studies as a moderating variable leading to a miss-out of the robustness of inferences; it is, therefore, hypothesised as follows:

H11. The influence of QEC, DEA and IMO on HI is significantly moderated by age.

Regarding education, it entails knowledge and skills acquired through the formal system (Hahn and Truman, 2015); it can also be acquired through the non-formal or informal system. Actually, education plays a central role in labour markets; in fact, there is overwhelming evidence that education correlates with earning (Jamison *et al.*, 2006; Card, 1999). For that, any inference that places less emphasis on education as an observable heterogeneity in predicting HI poses a significant drawback. Turčínková and Stávková (2012) stressed that the household whose head has primary or no education are vulnerable to income poverty. Therefore, resources availability could be beneficial to educated members than counterparts. This is because education is likely to provide planning skills, lobbying and ease access to and mobilisation of resources. In that line, this paper places emphasis on education as observable heterogeneity that could moderates constructs, thus, it is hypothesised as follows:

H12. The influence of QEC, DEA and IMO on HI is significantly moderated by education.

On the gender of household head, whilst it draws attention in development planning, its analysis has ambiguous inferences. In appraising it, Gonzales *et al.* (2015) induced that those women still, on average, have lower access to resources like financial services than men. This prompts difficulties in business start-up and therefore exacerbates inequality. Indeed, gender could, therefore, halt and determine income growth or not. Thus, from empirical reviews, this paper hypothesised as follows:

H13. The influence of QEC, DEA and IMO on HI is significantly moderated by gender

2. Methodology

The study was conducted in two districts of Kasulu (Kigoma region) and Uyui (Tabora region) in Western Tanzania. Four villages were purposively selected from each district based on being earlier recipients (six years) of electricity through rural energy agency (REA) and the state energy utility, Tanzania National Electric Supply Company (TANESCO). The regions where the district and villages were drawn are amongst the low-income earning, for example, in Kigoma about 48% lived below the basic needs' poverty line whilst Tabora had 32% (Kilama, 2016); thus, making it appropriate to investigate if the prevailing power supply has a causal effect on HI along with other resources as in Figure 1. Due to many interrelationships of variables in the theoretical model, quantitative design with unique PLS-SEM was used. The paper used the sample size of 374 households obtained through Yamane (1967) sample size formula. Further, a proportionate sampling technique was used to obtain a sample representative from eight villages of the two districts. Using a random number table, respondents were randomly selected. A bipolar scale of one to seven was used to collect data on measurable indicators. It was validated for face and content validity; it was reliable at 0.69 and 0.78, which is an acceptable range in social sciences (Heale and Twycross, 2015). Qualitative data were collected through focus group discussion to obtain more information for robustness of the inferences.

2.1 Measures

The measures for five unobservable constructs were developed and operationalised from empirical reviews (See Appendix). QEC was measured by five formative indicators: safety of supply and affordability were adopted from the multi-tier framework for power quality used in Bhatia and Angelou (2015), shock resilience was borrowed from Dzobo *et al.* (2012) and voltage stability from Chatterton (2014) whilst reliability was from Bhatia and Angelou (2015); Chatterton (2014) and Bastakoti (2003). DEA had five measures, namely workforce, information technology and communication, land, fiscal capital and social networking, all borrowed from Department for International Development (DFID) (DFID, 2000) in sustainable livelihood framework (SLF) but differently used by Steel and Van Lindert

(2017) and Peters *et al.* (2011). Nevertheless, on IMO, measures were as follows: self-realisation from Kéri (2018 in Udvari and Voszka, 2018), whilst desire for better living, personal satisfaction and safety were borrowed from Urošević *et al.* (2016) and responsibility from Lai (2011). The HS had two measurable indicators, namely background in wealth accumulation and experience and skills in resources mobilisation. The HI construct (had five measures too: assumed from Steel and Van Lindert (2017) was financial savings; micro-enterprise start-ups from Peters *et al.* (2011); Beéguerie and Pallière (2016) and Kumar and Rauniyar (2018); employment (Dinkelman, 2011) and electrical assets (United Republic of Tanzania, 2017) whilst owner-occupied dwelling was assumed from Lewis and Severnini (2019).

2.2 PLS-SEM description and justification

The paper used PLS-SEM with SmartPLS3.2 software (Ringle *et al.*, 2015). PLS-SEM is a causal modelling that maximises the explained variance of the endogenous construct (Hair *et al.*, 2014a). The paper applies a conceptualised model with latent constructs in Figure 1; thus, in models with latent variables, PLS-SEM is "virtually without competition" (Wold, 2006). Further, the paper uses the skeletal RBV theory; thus, PLS-SEM is useful for estimating and developing it (Hair *et al.*, 2014a). In fact, PLS is a full-fledged estimator for SEM (Henseler *et al.*, 2016) which in this milieu possesses Pareto efficiency over PSM, OLS, difference in difference estimator (DDE) and covariance based (CB)-SEM. It has strong causal effect predictive power and can be used for non-normal data (Hair *et al.*, 2014b), handle multicollinearity, robustness in the face of data noise and missing data (Garson, 2016). It is the finest second-generation technique (Hair *et al.*, 2014a), which enables the incorporation of unobserved and observable variables (Chin, 1998a). Although it has myriad algorithms, Hair *et al.* (2014c), PLS-SEM if appropriately applied is indeed a "silver bullet" for estimating causal models.

2.3 Data analysis and PLS-SEM algorithms

In order to test hypotheses stated in the theoretical model in Figure 1, the two-stage approach suggested by Hair *et al.* (2017) and Sarstedt *et al.* (2014) were used. The outer model was evaluated to establish if the quality criteria for formative and reflective construct were met whilst noting the relationship between observable and unobservable variables (Sarstedt *et al.*, 2014). The inner model evaluation involved path analysis based on the relationship between latent exogenous and endogenous construct. Hair *et al.* (2017) stipulated that PLS-SEM is robust on distribution assumptions; hence, significance and relevance of formative composite indicators, weight and path coefficients were tested by running a bootstrapping routine with samples resampled to 5,000 (Henseler *et al.*, 2016).

Three path models were run, first with and without mediator; the purpose was to test if HS mediator has a role on HI by comparing variance explained (R^2) values and path coefficients. Then, a path model with moderators (age, education and gender) was executed through bootstrapping routine to find out the effects of observable heterogeneity on exogenous latent constructs for vigorous inferences. The effect size (f^2) for exogenous latent constructs was calculated followed by blindfolding procedure for assessing predictive relevance of endogenous constructs through Stone–Geisser criterion (Q^2) (Vinzi *et al.*, 2010).

3. Results and discussion

3.1 Measurement model evaluation

The outer model assesses the contribution of each indicator in representing its associated construct and measures how well the combined set of indicators represents the construct (Duarte and Amaro, 2018). The current study's model has reflective and formative measured constructs (Table 1); thus, both the outer weights and loadings have been considered (Garson, 2016).

3.2 Reflective measurement model assessment

The structural model has two reflectively measured constructs (factor based). These included HS treated as a mediating variable and endogeneity HI. The model assessment results for convergent validity are presented in Table 1.

The convergent validity criteria in Table 1 indicates the extent to which indicators belong to one latent variable and actually measures the same construct (Benitez *et al.*, 2019). The convergent validity was assessed through indicator and construct reliability. For indicator reliability, all the outer loadings were significant at 0.01 level (bootstrapping routine with 5,000 resamples) and above 0.5 parameter value. Henseler *et al.* (2009) and Chin (1998b) suggested the indicator loadings to be at least 0.6 and ideally higher than 0.7: Vinzi *et al.* (2010) and Garson (2016) proposed a stringent rule "above 0.708". In a similar line, Avkiran and Ringle (2018) and Hair *et al.* (2014a, c) stipulated that indicator with weaker loading (below 0.4) should be ruled out from the scale especially if it leads to increase of AVE and CR; thus, outer loadings of 0.5 and above is adopted. To sum, the convergent validity results convey that each construct measures what it is supposed to measure.

The construct reliability and validity were tested through two indices (Rouf and Akhtaruddin, 2018): (1) composite reliability (CR) for HS was 0.848 and 0.792 for HI, all these values were above 0.7 which is a conservative cut-off point (Rigdon, 2013; Sarstedt *et al.*, 2017). Thus, all reflective constructs have better internal consistency; (2) Average variance extracted (AVE) which reflects the average communality for each latent factor in a reflective model (Rouf and Akhtaruddin, 2018; Hair *et al.*, 2017). For a good and adequate model, AVE should be greater than 0.5 (Höck and Ringle, 2006). In Table 1, AVE for each construct was above the limit; 0.657 for HS whilst HI had 0.537 providing that the constructs have captured more than 50% of the variance.

Nonetheless, discriminant validity (Table 2) is meant to ensure that a constructed measure is empirically unique and represents phenomena of interest that other measures in the structural model do not capture (Henseler *et al.*, 2015). This validity assessment is only limited to reflectively measured construct (Abdi *et al.*, 2013; Chin, 1998a); it was measured through Fornell–Lacker criterion and heterotrait-monotrait ratio (HTMT) (Richter *et al.*, 2016; Henseler *et al.*, 2015). For the Fornell–Lacker criterion, discriminant validity is measured by comparing the value of squared correlation between constructs and the AVE for the reflective constructs (Nikbin and Hyun, 2017). For well-established discriminant validity, the correlation value should be less than the square root value of the AVE along the diagonal as indicated in Table 2.

Construct	Code	Loadings	*T*-statistics	*p*-values	VIF <5	AVE >0.5	CR > 0.7
Household strength (HS)	HS1	0.764	14.602	0.000***	1.112	0.657	0.848
	HS2	0.855	26.603	0.000***	1.122		
Household income (HI)	HI1	0.708	22.720	0.000***	1.899	0.537	0.792
	HI2	0.908	74.741	0.000***	3.386		
	HI3	0.834	35.246	0.000***	2.198		
	HI4	0.510	8.271	0.000***	1.213		
	HI5	0.641	16.388	0.000***	1.394		

Note(s): ***Significant at $p < 0.01$; VIF = value inflation factor; AVE = average variance extracted; CR composite reliability and HTMT = heterotrait-monotrait ratio

Table 1.
Quality criteria for reflective model

The Fornell–Lacker criterion Constructs		DEA	HI	HS	IMO	QEC	Heterotrait-monotrait ratio (HTMT) HS → HI	95% CI
1	Development assets (DEA)	Formative model			Formative model	Formative model	Critical value < 0.85	
2	Household income (HI)		*0.755*				0.5	0.419–0.603
3	Household strength (HS)		−0.236	*0.811*				
4	Individual motivation (IMO)		0.397	−0.479				
5	Quality electricity (QEC)		−0.747	0.375				

Table 2.
Discriminant validity analysis

Thus, Table 2 provides that the square root of each construct's AVE along the diagonal is greater than its highest correlation with any other construct. This superiority validates the establishment and existence of discriminant validity (Chin, 2010). On the same, the HTMT ratio provides maximum supports for discriminant prevalence in PLS-SEM. Garson (2016) states that HTMT is the ratio between correlations of indicators across constructs measuring different phenomena to the correlations of indicators within the same construct. Henseler *et al.* (2015) and Gold *et al.* (2001) suggest that any HTMT value below 0.9 signifies the establishment of discriminant validity. Nonetheless, the critical value of 0.85 has been assimilated for decision (Kline, 2011); consequently, the results uphold that HTMT values of 0.5 favours prevalence of discriminant validity. Additionally, through bootstrapping routine, it was found that at 95% confidence interval the HTMT value did not exceed the range (0.419–0.603); thus, validity is established. Generally, these results indicate that HI and HS were correctly measuring different aspects; therefore, the results of prediction of the model remain valid.

3.3 Formative measurement model assessment

Hair *et al.* (2017) suggested consideration of collinearity, significance and relevance of outer weights in the evaluation of the formative model. Nevertheless, Rick and Jasyn in Avkiran and Ringle (2018) as in this study (Table 3) added and reported outer loadings for robustness of the assessment.

Table 3 summarises that the outer weights were below the limit of 1; hence, it indicates a stronger contribution to the construct (Garson, 2016; Rick and Jasyn in Avkiran and Ringle, 2018). Although the variables were within the range, they have different strengths in contributing to the construct. The weights can be estimated by partial multiple regression where the latent Y's construct turns to represent a dependent variable and associated indicators x's are the independent variables. According to Hair *et al.* (2017) and Garson (2016), outer weights show contribution (relationship) of indicators on the formative construct. Thus, the results indicate that the manifest variables have different contributions on the respective construct. All outer indicators were retained because they have significant outer weights ($p < 0.01$).

The outer loadings for formative indicators were above 0.50 cut-off point (Hair *et al.*, 2014a and Diamantopoulos, 2006) and were all significant at $p < 0.01$. It is noted that formative indicators do not necessarily correlate highly because they represent constructs independent cause (Edward and Bagozzi, 2000), neither are they interchangeable (Diamantopoulos and

Construct	Code	Outer weights $0 \pm > 1$	p-values	Outer loading	p-values	VIF<5
Quality electricity (QEC)	QEC1	0.563	0.000***	0.656	0.000***	1.260
	QEC2	0.226	0.002***	0.521	0.003***	1.484
	QEC3	0.782	0.000***	0.861	0.000***	1.165
	QEC4	0.701	0.000***	0.721	0.000***	1.448
	QEC5	0.434	0.000***	0.562	0.000***	1.120
Development assets (DEA)	DEA1	0.423	0.004***	0.600	0.000***	2.307
	DEA2	0.402	0.000***	0.534	0.000***	1.310
	DEA3	0.584	0.000***	0.658	0.000***	1.858
	DEA4	0.299	0.006***	0.742	0.006***	1.168
	DEA5	0.643	0.000***	0.702	0.000***	1.073
Individual motivation (IMO)	IMO1	0.341	0.003***	0.600	0.000***	1.414
	IMO2	0.473	0.000***	0.528	0.000***	1.363
	IMO3	0.507	0.000***	0.657	0.001***	1.261
	IMO4	0.599	0.000***	0.824	0.000***	1.506
	IMO5	0.700	0.000***	0.712	0.000***	1.432

Note(s): ***significant at $p < 0.01$ and VIF = variance inflation factor

Table 3.
The quality criteria for formative model assessment

Winklhofer, 2001). Generally, all conditions indicate that the model demonstrated no multicollinearity between indicators as verified through variance inflation factor <5 (Hair *et al.*, 2006; Diamantopoulos and Siguaw, 2006).

3.4 Structural model evaluation

PLS-SEM, unlike CB-SEM, does not have a normed and standard goodness-of-fit statistic (Henseler and Sarstedt, 2013); hence, it requires specification of a variety of parameters to confirm the model fit (Ma *et al.*, 2019). Thus, the structural model assessment quality (Figure 3) is based on the capability of predicting the endogenous constructs and associated criteria. Further, the structural model is based on testing the ascribed hypotheses.

In Figure 3, the inner model indicates substantial predictive accuracy with $R^2 = 0.610$ for HI, whilst HS had $R^2 = 0.341$; the latter is deemed good in consideration of the theory and potential antecedents, thus giving the model a nod of a good fit. For continued R^2 evaluation, Hair *et al.* (2014a) suggested a measure of effect size (f^2) for uncovering the magnitude of effects of exogenous latent constructs on endogeneity. The f^2 is estimated by assessing the R^2 value when an exogenous construct is removed from the model and see if it has a feasible effect on endogenous. The decision rule in assessing f^2 is based on the conservative cut-off points, 0.02, 0.15 and 0.35, respectively, representing small, medium and large effect (Hegner-Kakar *et al.*, in Avkiran and Ringle, 2018). Vinzi *et al.* (2010, p. 638) from Cohen (1988) proposed a formula Equation (1) for effect size in PLS-SEM (path model) as follows:

$$f^2 = \frac{R^2_{included} - R^2_{excluded}}{1 - R^2_{included}} \quad (1)$$

$R^2_{included}$ is the value of R^2 of endogenous construct when a specific exogenous construct is included, whilst $R^2_{excluded}$ is the value when a construct is excluded in running PLS algorithm. The path model in Figure 3 shows the value of R^2 when all *Y1* (QEC), *Y2* (DEA) and *Y3* (IMO) are included in the PLS algorithm. The f^2 for HS and HI are indicated in Table 4.

In Table 4 it is shown that QEC has higher effect size on all endogenous variables, 0.098 for HS and 0.861 for HI. In fact, QEC surpasses other resources in adding strength to the household and in predicting income through sophisticated economic livelihood activities and

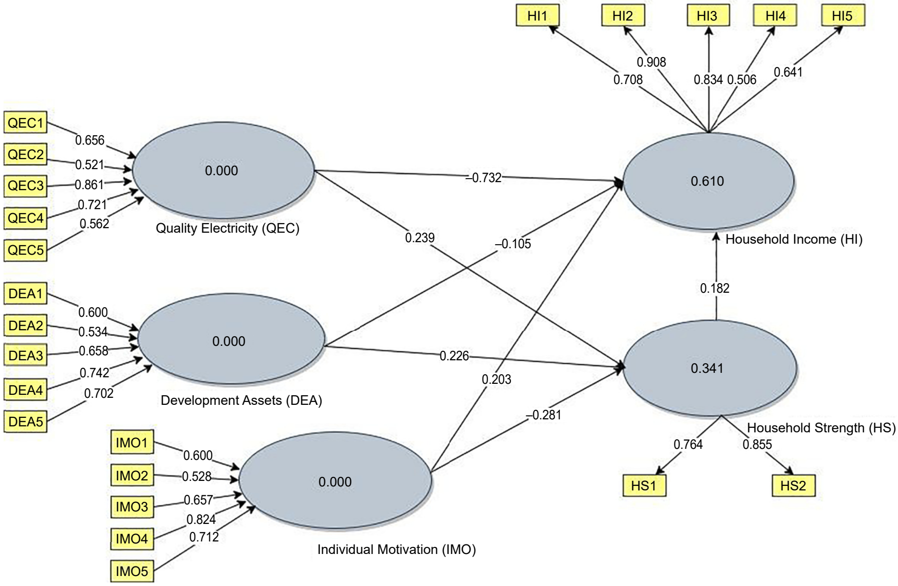


Figure 3.
A path analysis

Table 4.
The effect size of exogenous on endogenous constructs

Sn	Inclusion and exclusion condition	HS	f^2	HI	f^2
1	R^2 when *Y1, Y2* and *Y3* are include	0.341		0.610	
2	*Y1* (QEC) excluded	0.276	0.098	0.274	0.861
3	*Y2(DEA)* excluded	0.286	0.083	0.604	0.053
4	*Y3(IMO)* excluded	0.281	0.091	0.585	0.064

reduced cost on household sustenance. The DEA and IMO have very small effect size on both constructs. Apart from effect size, Stone–Geisser criterion (Q^2) for evaluating model's predictive relevance was conducted through blindfolding procedure with an omission distance of seven (Sarstedt *et al.*, 2014). Whilst Vinzi *et al.* (2010) suggested the use of construct cross-validated communality (Q^2), Hair *et al.* (2014a, b, c) recommended construct cross-validated redundancy (Q^2) which this paper adopts because it focusses on outcome constructs. The prognostic results hiked above the conservative bottom-line value of zero (Avkiran and Ringle, 2018) for each endogenous construct, i.e. for HI the $Q^2 = 0.317$ and HS = 0.20 confirming model fit. For a similar disposition, the q^2 effect size was assessed (using blindfolding Q^2 value) for the relative impact of predictive relevance; like the f^2, it follows 0.02, 0.15 and 0.35 stringent rule and similar calculation process Equation (2)

$$q^2 = \frac{Q^2_{included} - Q^2_{excluded}}{1 - Q^2_{included}} \quad (2)$$

Thus, when *Ys* are excluded, the Q^2 values for HS and the q^2 *effect* in parentheses were $Y1 = 0.129$ (0.043), $Y2 = 0.129$ (0.043) and $Y3 = 0.147$ (0.021). The reality is undeniable and all exogenous constructs had small predictive relevance on HS. For HI, the Q^2 values when *Ys* are excluded with q^2 effect size in parentheses were $Y1 = 0.102$ (0.292), $Y2 = 0.304$ (0.001) and $Y3 = 0.299$ (0.008). Accordingly, the result indicates that QEC (*Y1*) had approximately large predictive relevance on HI beating the odds; it proves empirically to be an important element compared to other antecedents.

Evaluation of significance and relevance of path relationships which was conducted through bootstrapping routine for 374 cases had 5,000 resampling and no sign changes option (Hair *et al.*, 2017; Vinzi *et al.*, 2010). In Table 5, the bootstrapping results are presented.

The result in Table 5 affirms that for direct effect, the path of DEA → HI (H3) was rejected ($\beta = -0.105$; it was not at $p < 0.05$; it upholds the absence of DEA's direct effect on HI. For that, HI can be contributed to by other constructs or through complementarities. Further, the antecedents articulate that having resources is one thing and turning them into direct HI is another phenomenon. Briefly, on HI, it is depicted that QEC → HI path had very strong prediction power than the rest ($\beta = -0.732$; $p < 0.01$); for one unit decrease of QEC, there is −0.732 decrease on HI. Nonetheless, the path of IMO follows with strong prediction power on HI ($\beta = 0.203$; $p < 0.05$). This depicts that whilst electricity plays a monumental role in predicting HI, it cannot suffice alone unless it is combined. Although DEA was not significant on HI, it adds on HS ($\beta = 0.266$; $p < 0.01$) whilst IMO add strongly significantly also ($\beta = 0.281$; $p < 0.01$). In fact, all resources add on HS which is an important element in propagating HI through the indirect path.

3.5 Mediation analysis

Mediation analysis in Table 5 advocates the presence of full and partial mediation (Vinzi *et al.*, 2010; Hair *et al.*, 2014a, b, c). Since the direct path of DEA to HI was insignificant ($\beta = -0.105$; $p < 0.05$), upon mediation the path became significant; hence, it is illustrated that HS fully and strongly mediates the effects of DEA on HI ($\beta = 0.049$; $p < 0.05$). This indicates that DEA as suggested in RBV guarantee less HI unless the quality and strength of the household has been considered or otherwise it is "poverty amid resources". Moreover, IMO was found to have effect on HI through HS ($\beta = -0.051$; $p < 0.01$); this was a partial mediation because although the direct effect was significant as well; upon encountering a mediator, the relationship was triggered to negative.

More importantly, the effects of QEC on HI is partially mediated (with the change in direction of effect) by HS ($\beta = 0.044$; $p < 0.01$). The effects signify that in making HI better, no single resources can suffice. Nevertheless, the effect of electricity on HI is crucial but not enough to bring HI to a higher stage. For robust inferences about mediation effects, Vinzi *et al.* (2010) and Avkiran and Ringle (2018) suggested an independent structural path model that does not include a mediator (Figure 4). The standard guideline for assessing mediation effect

Path	Hypotheses	Path coefficient	*T*-statistics	*p* values	Supported
Direct effect					
QEC → HI	H1	−0.732	22.43	0.000***	Yes
QEC → HS	H2	0.239	6.792	0.000***	Yes
DEA → HI	H3	−0.105	1.348	0.178	No
DEA → HS	H4	0.266	5.265	0.000***	Yes
IMO → HI	H5	0.203	3.463	0.001**	Yes
IMO → HS	H6	−0.281	5.958	0.000***	Yes
HS → HI	H7	0.182	5.040	0.000***	Yes
Mediation analysis					
QEC → HS → HI	H8	0.044	4.224	0.000***	Yes
DEA → HS → HI	H9	0.049	3.507	0.000***	Yes
IMO → HS → HI	H10	−0.051	4.148	0.000***	Yes

Note(s): ***Significant at $p < 0.01$

Table 5. Bootstrapping results for direct and indirect paths

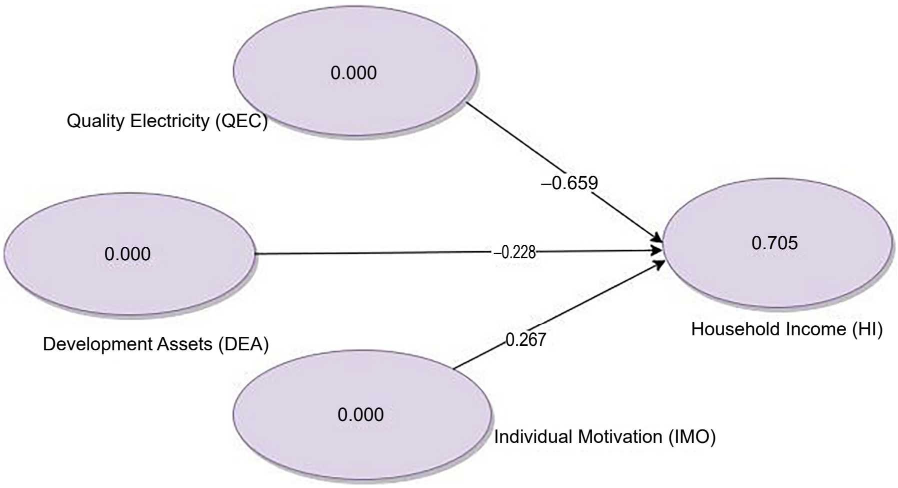


Figure 4.
Path analysis (impact without a mediator)

(R^2, f^2 effect size and Q^2) was adopted from Avkiran and Ringle (2018), Abdi *et al.* (2013) and Vinzi *et al.* (2010).

For variance explained, there was a substantial increase on R^2 for HI endogeneity with a mediator from R^2 = 0.610 in Figure 3 to R^2 = 0.705 without a mediator in Figure 4. The shrinking R^2 value of HI in the mediated model is a shred of analytical evidence that some of the effects of the exogenous construct are channelled through the mediator. Accordingly, an increase of the R^2 in a model with no mediator indicates that the effects which were held in mediation have been released to some extent. The R^2 and f^2 effect size for exogenous construct on HI endogeneity in parentheses were as follows: QEC = 0.366 (1.149), DEA = 0.653 (0.176) and IMO = 0.654 (0.210). It is evident that QEC is far better with very high effect size and it is superior than DEA and IMO in predicting HI with strong path coefficient. Similarly, the predictive relevance Q^2 value was 0.361 for HI indicating the best fit because this value is > 0. Regarding the significance of paths, QEC to HI coefficient value for an unmediated model (Figure 4) has shrunk unlike in Figure 3; this is an expression that when QEC is intertwined with intermediaries, the prediction becomes substantial. Moreover, DEA in Figure 3 does not predict HI but when a mediator is excluded DEA effects become real (−0.228; $p < 0.01$), demonstrating that some resources can just help income generation even if intermediaries are rare.

3.6 Moderation analysis (observed heterogeneity)

Table 6 shows the relevance of the prior variable and uncovering the observed heterogeneity effects regarding the inner constructs. The paper executed heterogeneity using the three moderators: age, education and gender of the household head. The HI had a substantial increase in R^2 from 0.610 (Figure 3) to 0.715. This indicates the presence of significant moderation effects of the variables on exogenous constructs.

The results in Table 6 illustrate that the influence of QEC on HI is strongly moderated by education ($\beta = 0.246, p < 0.01$) whilst the effect of IMO on HI is strongly moderated by gender ($\beta = 0.209, p < 0.01$). The results deduce that a household could reap income regardless of the moderating variables in some context. Generally speaking, having QEC with the complementarity of education surely exacerbates the likelihood of yielding substantial HI; this could be through micro-business start-ups such as TV show centres, milling machines

Table 6. Bootstrapping results for moderator analysis

Paths	Hypotheses	Path coefficients	*T*-statistics	*p*-values	Support
Age					
*QEC → HI_	H11	−0.025	0.404	0.686	No
*DEA → HI_		0.068	0.219	0.827	No
*IMO → HI_		0.058	0.502	0.616	No
Education					
*QEC → HI_	H12	0.246	2.927	0.004***	Yes
*DEA → HI_		−0.270	0.695	0.487	No
*IMO → HI_		0.133	1.536	0.125	No
Gender					
*QEC → HI_	H13	−0.013	0.252	0.801	No
*DEA → HI_		−0.019	0.278	0.781	No
*IMO → HI_		0.209	4.136	0.000***	Yes

Note(s): ***significant at $p < 0.01$

and restaurants which are some of the features of rural business. More importantly, IMO works well when gender is considered. For example, looking at the traditional stands and practices in the study areas, men are obliged to provide for the family and thus prompted and extrinsically motivated them to go out probing for economic success. Although women play a large part as well, that has not changed men's dominance in income roles. However, although age and education do not influence DEA and IMO in predicting HI, this could only be statistical evidence; but practically, they could predict income at the household. For example, DEA like land, access to fiscal resources, information and technology could have a large effect in predicting HI only if they are presented to the educated people than the counterparts.

3.7 Discussion

The paper aimed to (1) examine the influence of QEC, DEA twined with IMO on HI and (2) evaluate the mediating effect of HS and moderating roles of priori variables in perpetuating HI. This paper extrapolates that QEC surpasses DEA and IMO in predicting HI. This was confirmed through alternative hypotheses which indicated electricity had very strong prediction power on HI through direct paths to endogeneity. With QEC, people no longer travelled long distances for some services like milling in rural areas. All these have led to the drastic decline of service costs leading to the increase of financial saving baskets at the household. Information from the focus group discussion showed that on milling services, there was a decline of price up to 70% after electricity connection; for example, in Uyui (Ilalwansimba Village) with diesel-powered milling machine, the cost for husking a bucket of paddy was Tanzanian Shillings (TZS).3 500/ = before electricity connection. Equally, after electricity connection the price shrunk to TZS.500/ = this was contributed to by dependence on electric powered milling machines. In furtherance, the consensus from the FGD (Focus Group Discussion) was that

> . . .. having electricity is something to cheer up because most of the services here in our village have gone down. Currently, we have only one diesel powered milling machine which operates as a backup in case of an outage. The price we pay on diesel powered milling machines is higher compared to that we do on electric motored milling machines. . ..

The above information from the FGD means that the respondents no longer incur many costs on some sustenance services like milling. This is an indication that there is an income increase as the results of reduced expenditure caused by electricity connection in rural areas. This is key evidence of short-term effects related to income acquisition.

Apart from the declining cost of services on milling, it was also indicated that some other services such as kerosene were reported to be high whilst offering less comfortability to users. Night studies for schooling kids were reported to drain money for kerosene before electricity connection. This changed after electricity connection; respondents had saved a substantial amount of money after cutting cost from kerosene. These results corroborate the findings by Mazumder *et al.* (2011) who reported that in Dumuria and Bangladesh rural areas, electricity had led to the decline of kerosene dependence, thus reducing expenditure as well.

Moreover, another notable benefit of electricity on business operators was noted. The milling services after electricity connection shifted a paradigm. In Kabanga Village of Kasulu District, all milling machines of diesel type were substituted with electric motor-powered milling machines. This was because operating a diesel-powered machine was expensive and the margin was little. The most hitting challenge was the high price of fuels which was not predictable as well. The shift of paradigm went hand in hand with increased milling machines which offered diversity of services from grinding to husking. For that, respondents did not travel to the far town areas to seek milling and husking services for maize and paddy.

Similarly, with electricity availability in the rural areas, there was increased employment resulting from new firms like metal welding, brick making, restaurants and carpentry. The new firms were directly linked with the use of electricity. New business like food vending along the road was reported as another source of job creation and income growth. In fact, on employability, the results are consistent with Dinkelman (2011) who reported that electricity plays important roles in accentuating employment to women by enabling them to allocate more time in productive activities. On firms' development, it is in line with Burlig and Preonas (2016) who found that with electricity availability there is new capital invested in small modern firms such as kioski and hair salons. However, the results contradict Matinga and Annegarn (2013) who reported electricity having no effect on business and small firms. Electricity influences purchase of domestic assets used for collaterals in accessing financial services (United Republic of Tanzania, 2017). The common electrical asset was TV and home theatres to those who owned TV show centres in their premises. Electricity has also led to housing furnishing and modification and hence increased asset value. The result is analogous to Lewis and Severnini (2019) who inferred that electricity in rural areas had led to increased asset value, such as housing and land. The value increase is due to the fact that electricity attracts population growth in some centres which also leads to demands of services such as houses for rent.

Further, the paper enumerates that DEA and IMOs should not be underrated in bringing income on stage because they have a positive effect as also found by Lenz *et al.* (2016) and Torero (2015) that complementarities are useful in accentuating income as well. Although the alternative hypotheses of the influence of DEA (land, access to financial services, information and technology) on HI were rejected, upon encountering the mediator, it showed significant prediction. Therefore, different resources have a significant contribution to HI. Although QEC has emerged to be a powerful predictor of HI through large effect sizes, it alone cannot work better. Electricity should also be considered as a stimulant of income given the availability of all necessary conditions because a single resource which is rare, imitable and valuable or vice versa cannot affect income.

The paper empirically demonstrates that HS as an intermediary is imperative for effective use of resources. The ability of the household to mobilise available resources is vital for firm start-up, planning and decision-making. Weak households cannot generate income even if they are presented with the necessary resource; speaking of that, the paper advises that for resources to have effects on HI, the strength of a household as an intermediary should become a genuine consideration. This is supported by the alternative hypotheses which were significant based on the indirect effect of HS's ability to transmit effect from electricity and DEA.

Moreover, the paper authenticates that complementarity of education and gender is paramount in ensuring significant effects of electricity and IMO on income. This inference is in line with that of Lenz *et al.* (2016) and Shahabadi *et al.* (2018) that education better complements electricity in crafting HI. In fact, with QEC, education offers the ability to discover an array of income generation opportunities just like gender does on IMO. Gender determines the level of intrinsic or extrinsic motivation towards income generation if it is discounted from development actions it impairs the efforts and household success in income generation as also reported by Urošević *et al.* (2016).

4. Conclusions and recommendations

The improving rural households' income in Tanzania requires multi-dimensional and coherent approaches; but for visible results, electricity is not an option but "quality and affordable electricity" remains to be as indicated through H1. Whilst that is empirically substantive, also the hypotheses tested (H2, H4, H5, H6, H7, H8) showed that principal resources like land, technology and communication need an acute consideration as important complementarities in the work of income generation. In fact, electricity is a stimulant of income generation if merged with locally available resources and human behavioural traits based on motivations. Further, the arrays of business opportunities and ability in reducing life sustenance costs should not be considered as directly related to electricity but also to the strength of households. Relating HI with a single factor of electricity is a drawback; thus, a list of conditions and resources play vital roles in HI generation.

In rural areas whilst the energy utility increases the efforts in reduction of electricity poverty, it should not be seen as the end but the beginning for ministerial actions to ensure the standard environment for income growth. There must be ministerial cross-cutting engagements in creating conducive and sounding opportunities for small business in rural areas to fasten income generation. In that continuum, access to roads, market for agricultural produce, financial services and information and communication technologies must all be ensured by the responsible ministries and local authorities in making income acquisition a simpler equation for a sustainable benefit.

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Appendix

Code	Quality Electricity-QEC (Y1) exogenous	Details
QEC1	Reliability of network of supply	Electricity is available most of the time is needed
QEC2	Voltage stability	Electricity is capable of running available appliances
QEC3	Safety of supply	Electricity does not cause an accident
QEC4	Affordability of consumption	Consumers spend no more than 5% of income on electricity
QEC5	Resilient to shocks	The network system is not vulnerable to shocks
Development assets -DEA(Y2) exogenous		
DEA1	Workforce	There is the skilled, semi-skilled and unskilled human workforce
DEA2	Information and technology	Information accessed lead to economic activity decision
DEA3	Land	The land is adequate and fertile for economic activities
DEA4	Fiscal capital	Feasible access to financial resources to start enterprises
DEA5	Social network and connection	Well linked with others for economic benefits
Individual motivation -IMO (Y3) exogenous		
IMO1	Self-realisation	There is the fulfilment of one's potential
IMO2	The desire for better living	Innate feeling and desire to better oneself, growth and advancement
IMO3	Personal satisfaction	Setting income as a goal of happiness
IMO4	Acceptance and recognition	The feeling of being part of the surrounding starter society
IMO5	Responsibility	Driving forces for income generation and being dependable
Household strength (HS) endogenous		
HS1	Background in wealth ownership	The household has a long history of wealth ownership
HS2	Skills in resources mobilisation	There are skilled members with resources mobilisation skills
Household income -HI (Y5) endogenous		
HI1	Financial savings	Gain fund as a result of reduced life costs
HI2	Enterprises start-ups	There are emerging enterprises in the local environment
HI3	Employment	Emerging job creation amongst the population
HI4	Domestic electrical assets	The household has valuable electrical assets
HI5	Owner-occupied dwelling	Value of the dwelling unit increased due to electricity

Table A1. Definition of variables used in PLS-SEM

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