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Determinants of Upgrading Micro-Manufacturing Enterprises: The Case of Metalworks in Morogoro Municipality in Tanzania

Longinus Rutasitara[1] and Onesmo Selejio[2]

Abstract

This paper examines the factors that influence innovation-led enterprise upgrading of micro-manufacturing enterprises (MMEs) in the metalworks sub-sector in Tanzania. Following a desk review, primary cross-sectional data were collected from 285 randomly selected metalworks enterprises in Morogoro municipality. Most enterprises are micro- (employing an average of 2 people) and are informal (73.7%). Probit model results confirm that the age of the owner, education level, working environment and public sector policies have a positive and significant influence on innovation, while the household size variable is innovation-inhibiting. OLS regression results show that, for registered enterprises, the use of modern technology, the experience of the owner and market competition are innovation-promoting. Being a cluster member has a positive growth effect as it provides access to modern technologies and markets. The findings point to a need for intensified efforts to accelerate technical education, deepen training in relevant skills, facilitate formalisation and reinvigorate cluster initiatives. Public policies need to be transparent and supportive of an environment in which the MMEs innovate and grow.

Keywords: Upgrading, micro-manufacturing enterprises, metalworks, technology, formalization

Introduction

Tanzania's Integrated Industrial Development Strategy 2025 (IIDS) (URT, 2011) called for interventions to 'upgrade' indigenous micro-manufacturing enterprises (MMEs) as part of the 'bottom-up local industrialization' (URT, 2011). 'Upgrading' in this case implied enabling largely informal (small) manufacturing enterprises to make productivity and competitiveness improvements through modern technological innovations. In turn, this would make industrial development more 'inclusive' at the same time as it expands the country's industrial base. In part, the IIDS was alluding to the historical public policy bias in developing countries that favoured well-placed large enterprises through easier access to subsidies and imported technologies while small, local enterprises got little attention (ILO, 2022; UNCTAD, 2001). Even under import substitution industrialisation, large industries still attracted such favours (Helmsing and Kolstee, 1993). Lack of requisite skills for innovation and limited budgets for Research and Development (R&D) continue to undermine the ability of light manufacturing enterprises in Africa to graduate into mid-sized enterprises or larger (Dihn, Palmade, Chandra and Cosart, 2013).

[1]University of Dar es Salaam School of Economics,
Email: ruta6ra@gmail.com
[2] University of Dar es Salaam School of Economics,

Recognising the need for increased productivity-enhancing innovations, Tanzania established the Small Industry Development Organisation (SIDO) in 1973 to provide support to indigenous entrepreneurs in technological development and transfer, market information and financial services. Related interventions included the Vocational Education and Training Authority (1994), the Small and Medium Enterprise Development (SME) (URT, 2003), and SME credit guarantee scheme (2005) administered by the Bank of Tanzania. Further, the cluster initiative was established in the 2000s aiming to strengthen joint access to manufacturing technologies for SMEs by providing options for SMEs to network with public policy and academic-cum-research institutions. However, small industrial enterprises are still facing growth constraints: What should be done to enable local micro-manufacturing enterprises acquire technological capabilities to scale up output and quality? To contribute to this question, this paper focuses on the metalworks sub-sector from within the manufacturing sector [(Section C) in the ISIC Rev.4 (UN, 2008) 23, 24 and 25]. At least three reasons explain this focus. First, in many developing countries, the metalworks sub-sector hosts many informal micro and small enterprises which to some extent relieve unemployment (O'Regan, Wescott and Butler 1989; Charmers and Wunsch-Vincent, 2016). The sub-sector is a venue for the creation and absorption of new technologies and skills, a precondition for progress into more complex, modern metalworking operations (UNIDO, 1980).

Second, metalworks operations - from welding, drilling, threading, soldering, sawing, machining etc. all the way to more sophisticated ones such as use of laser-cutters - have linkages with several sectors like agriculture, transport, construction, real estate, automotive and aviation sectors, health sector equipment, oil and gas (Schlick**,** 2023). However, in many developing countries, metalwork products are not sophisticated. The metalworks MMEs are small and informal, catering to the lower-income population in rural and peri-urban areas. Innovations leading to upgrading of their technological capacities are key to enabling them to catch up on the rapidly evolving global standards and to participate in higher-value processes, such as in the mining and gas sectors (Gray and MacMillan, 2016; MRDC, 2014). Apart from informality in terms of non-registration, MMEs pose environmental and health concerns related to location of work premises and human settlements mainly in urban and peri-urban areas (Igu, Ajibo and Ayogu, 2023; Ramanathan, He, Black, Ghobadian and Gallear, 2017; Okuga, Mayenga and Bazeyo, 2012).

Third, African countries like Ghana, Uganda, Tanzania, and Ethiopia experimented with an ‘industrial cluster' approach to help groups of small enterprises access technological support and markets. In Tanzania, the first metalworks clusters are noted in Gerezani, Dar es Salaam in the 1970s. A more prominent initiative was supported under the "Innovation Systems and Cluster Development Programme Tanzania" *(ISCP-Tz)* in the mid-2000s. In 2006, there were 8 such cluster initiatives, one of which was the Morogoro Metalworks Cluster Initiative (Mwamila and Temu, 2006; Diyamett and Komba, 2008). By 2015, there were more than 70 of them (Stadenberg, 2016; Landa 2015). The clusters are nevertheless known to suffer from sustainability issues where donor/assistance ceases and mistrust among some member SMEs (Rath, 2018, Herr and Nettekoven, 2017).

It sounds timely for an updated and more incisive study on the current state of the cluster initiatives in Tanzania. However, the present study does not specifically target clusters. It sets sight primarily on the MMEs regardless of their association status. This is partly due to the fact that not all industrial SMEs take part in the industrial clusters - particularly those industrial SMEs that are informal. The objective of this paper is to examine factors that affect innovation-led upgrading for MMEs in the metalworks sub-sector in Tanzania. Three related questions are:

- What entrepreneur characteristics affect the MME's ability to attain innovation-led upgrading?
- What firm characteristics enable the MMEs to attain innovation-led upgrading?
- What external environment factors enhance MME innovation-led upgrading?

Two related factors underscore the significance of this study: the established direct association of availability of power and performance of manufacturing enterprises, including enterprises in rural areas (Olanrewaju, 2019; Tiku, 2019; Bose, Uddin and Mondal, 2013; Maleko, 2005). Tanzania's recent increase in power generation capacity and accelerated rural electrification will support rural MMEs, along with a rise in household demand for metalworks products from a growing population. Tanzania's population (61.9 million of which 65.6% in rural and 34.4% in urban areas) is projected to double by 2044 (URT, 2024). In Tanzania, metalworks MMEs are found in nearly all urban and peri-urban settlements. Morogoro Municipality is one of the urban areas in the country that attracted cluster initiatives along with Dar es Salaam, Arusha, Mwanza and Mbeya (Landa, 2015). However, many MMEs remain in business outside clusters, being largely informal and surviving on meagre innovativeness. Many studies, including the present study, acknowledge the paucity of data as many informal SMEs do not keep good records. However, the surveys are so designed as to elicit qualitative as well as quantitative information adequate to make reasonable conclusions. The present study took this into consideration. It is fair to suppose that the results of this study can potentially be generalised in support of the MMEs of the developing countries.

Innovations-led Upgrading for SMEs: Global Perspectives

A firm seeks to maximize profit while markets determine the level of achievable profit and the relative prices, and hence, the factor proportions in the production function. Since markets are imperfect, market operations are not costless. An entrepreneur takes centre stage, stepping forward as a risk taker and innovator who makes strategic combinations of inputs, available technology and skills of workers. In the Schumpeterian sense of 'creative destruction', an innovator uses discovered inventions to alter combinations of inputs to set up a new or improved process or product variety (Kesper, 1999). Resulting 'novelties' in terms of innovation related to the process, product, marketing and organisational breakthroughs may eventually wipe out existing designs or models from the market and replace them, over time, with entirely new ones (Rosenberg 1982). The impact of a successful innovation of a firm, internally generated or acquired, is reflected in the firm's value, profits, revenue, productivity and market shares.

In literature, the capacity to 'upgrade' is often associated with the capacity to innovate, hence the exploration of what drives a firm's innovation capabilities. Reeg (2013) depicts upgrading as enterprise growth triggered by 'innovation' while Loewe *et al*. (2013) argue that what an enterprise can control is growth through innovation. The concept of enterprise upgrading invokes the Reeg (2013) 'onion' model in which the determinants of innovations are presented in successive shells or circles. At the innermost core are entrepreneur characteristics (such as age, level of education, gender, behaviour). The conceptual framework for the analysis of factors influencing innovation-led upgrading is summarised in Table 1. Factors internal to the firm, firm characteristics, and networking issues, including location, workforce characteristics, inter-firm linkages, and connection to value chains. The third 'shell' is the external environment, which includes public policies - regulation of labour, inputs, final products, technology and market competition.

In general, innovations of products, processes, and marketing and organisational strategies are generated internally by the firm through in-house R&D or outsourced R&D. The diffusion theory (Rogers, 1983) explains how the new innovations or such ideas are passed on, adopted and further adapted by different users. In advanced countries, R&D is a leading source of innovations for both large and SMEs (OECD, 2000). High levels of human capital and budget support a wide range of R&D activities, quite unlike those in developing countries. Public policy supports the national entrepreneurial class by investing in critical knowledge infrastructure and in accessing information on new technologies and foreign markets to enable domestic firms to keep abreast with global competition (James, Naya, and Gerald, 1987; UNCTAD, 2001:8).

Table 1: Factors Affecting the Prospects of Innovation-led Upgrading

Internal-to-the-firm factors		**External Environment**
Entrepreneur characteristics	Age; education; technical training; behaviour (risk-taking, innovativeness, resilience, vision, willingness to network/cluster	-Public policy (investment incentives; regulatory framework; taxes and levies; local government by-laws; safety, health, and environmental standards; -international competition.
Firm characteristics	Size (employment); location and working space; storage; fixed capital equipment; type of technology; financing' human capital (skill levels, training, retaining); marketing (inputs, outputs; domestic; foreign)	
Networking (inter-firm linkages)	Cluster initiative/ relationships; connection to value-chains	

Source: based on Reeg (2003)

Apart from the R&D-based innovations, another source of innovation centres on the opportunities for productivity improvements through continuous learning-by-doing, 'learning by using', on-the-job training and apprenticeships (Korku, 2021; Rizk *et al*., 2018; Muthoni, Omato and Kithinji, 2013; Rosenberg, 1982). Although this form of informal innovation is possible even in advanced countries, it has been more closely scrutinised in informal SMEs in developing economies. It is a form of innovation that does not entail significant direct expenditures, but despite measurement difficulties, the 'incremental' impact on the firm's productivity growth is widely upheld (Voeten, Kirama and Macha, 2016). This is akin to "frugal innovation" - the term attributed to Fu (2020) - as that innovation in the informal sector that occurs in situations "…of a lack of capital, both human and physical, and underdeveloped diffusion systems of foreign and local technology, including knowledge" (Mehra and Moreira, 2022). From the operations viewpoint, the entrepreneur is seeking to attain optimal sequencing of tasks – from procurement of inputs, production process scheduling, marketing and optimal inventory management of inputs and outputs. Even if MMEs under consideration may not be acquainted with formal quantitative techniques of optimisation, the MME's entrepreneur is under pressure to garner innovations be they internally or externally generated.

Metalworks MMEs in Developing Countries and Tanzania

Emerging from the colonial period, most developing nations took off from the remnants of pre-independence traditional metalwork crafts. Attributes of early to advanced states of metalworking enterprises in developing countries are well-documented. Iles (2017) outlines some of the techniques used by smelters and smiths in the pre-colonial era in African countries. O'Regan, Wescott and Butler (1989) profile the prominence of early ('traditional') metalworks in rural and urban areas in Malawi. Small, urban-based metalworks enterprises enjoy location advantage due to easier access to supplies of inputs, in contrast to village-based tinsmiths. However, the skills, type of tools and equipment are listed as limiting factors. In addition, although the MMEs have a comparative advantage in the form of low overheads, adjustable production schedules and just-in-time inventories, low technology and skills severely limit their capacities to compete against imported products and expand scale. As in many African countries, MMEs are located on road reserves or in the backyards of homesteads due to a lack of affordable permanent and well-located sites. A closely similar situation is found in most African countries. In South Africa, Petersen *et al*. (2013) noted the emergence of MMEs in townships although unlike in SSA, the majority of the initiators of MMEs in the South African townships have higher levels of education and training.

To what extent do studies on MMEs provide leads on entrepreneur attributes or which firm characteristics and which external environment factors emerge as more promising in enabling MMEs to upgrade? Not all studies sampled cover these questions in this order or in equal depths. However, human capital, stated variously as knowledge and skills, comes across as vital, not only for the entrepreneur but also for 'how many and how well-trained and experienced' the employees are. This defines how quickly the firm can create new inventions or absorb new ones from other firms or from research, as well as how the firm positions itself to make the best out of the external environment. The various angles of enhancing MMEs human capital in order to innovate or adopt new innovations are addressed differently by different studies:

First, in a survey of 20 informal manufacturers of agricultural technologies in Harare, Manyati and Matsau (2020) explore the factors that determine the development, adoption and diffusion of innovations. Their desired outcomes of upgrading are in product development and fair competition in the commercialisation of their innovations. Limited knowledge of intellectual property rights and low education for both enterprise managers and employees which forces them to rely on experience and on-the-job training. The study expresses the recognition of the owners of the need for strengthened knowledge and skills. A second angle of human capital development, entrepreneurship orientation, is deduced from Ubele and Okwelle (2020) and Venatius, Musta'amal, Ekwok and Edet (2021). The two studies make a case for improved delivery of entrepreneurship education and competencies in order to enable the graduates to be self-employed in the sub-sector. Ismail (2010) advocates well-planned course materials and proper teaching methods on entrepreneurship to shape the graduates' technical-cum-business skills in Nigeria while Kiyabo and Isanga (2019) survey of 300 owner-managers of welding SMEs in Dar es Salaam, Morogoro and Mbeya amplifies the learning impact on entrepreneurship.

The quest for better technical capabilities is also raised by Thomas (2011), based on a survey of small metalworks enterprises in Kinondoni District in Dar es Salaam (Tanzania). In that survey, Thomas (2011) compares a set of 'entrepreneurs with apprenticeship-kind of training conducted by the government-sponsored Vocational Education and Training Authority (VETA) and 'entrepreneurs without VETA training'. Since the latter set performs relatively poorer than the former, the study proposes intensifying capacity development for the teaching staff of VETA colleges and more financial resources to acquire new equipment used as teaching aids. Fourth, Keshwani, Jagtap and Opiyo (2023) choose one of the entry points for innovation – product design - by informal MME. This study cover 24 informal metalworking microenterprises in Dar es Salaam and Coast Regions of Tanzania. It demonstrates that even with little or no formal education/training in product design, entrepreneurs and their teams of workers are able to design and fabricate products according to customers' preferences. Customer needs are identified, the concept developed, followed by a discussion between the customers and entrepreneurs to agree on final specifications. The study shows a marked difference in product design between graduates of a university and a technical college and employees or owners with lower levels of education and training.

With regard to the external environment, at least two studies may be cited. First, Mmasi and Mwenisongole (2010) demonstrate the benefits that derive from accessing information on the required standards like product quality, safety of the products and safety for workers and the environment at the workplace. The study found that entrepreneurs who operated "under SIDO's supervision" performed better than those operating "outside SIDO's supervision"; the latter did not benefit from SIDO's instructions. The study further shows the positive impact of work and business (policy) environment on enterprise performance, the fact that is also observed by Zhao, Yi, Zhan, and Guo (2022) in China and Lambert and Deyganto (2023) in Ethiopia. Osano (2021) makes yet another important reference to the firms' external environment, in particular, dealing with the client-base. In particular, the study examines the pricing strategies (the value-based pricing practice, competition-based pricing and cost-based pricing practice) of small-scale metal mechanics and fabricators in Mwanza city (in Tanzania). The study covers automotive metal parts makers, aluminium doors and windows makers, fabricators of security metal guards (grills) and metal fabricators. Dealing with the customer base is one of the operations of the MMEs owners as they seek to maximize sales.

Despite the apparent misgivings about the prospects of MMEs in many developing countries and in Tanzania, experiences from the metalworks industries in the Philippines are worth considering. MRDC (2014) surveyed a variety of metalwork tasks and products, ranging from parts and materials for the construction of houses, bridges, pipelines, and even massive offshore oil and gas rigs. The report shows that the transport sector took up to 53% of the welding services (body building, repair of parts, fabrication of iron and steel products), and agricultural and food equipment. The report ordered the surveyed urban and rural metalworking shops into single proprietorship (85%), followed by corporation (formally registered) (7%), 1% government institutions and 5% not disclosing. Further, out of the 634 shops, 80% were micro (1-9 personnel); 72% of the employees had formal education. The workers possessed high technical capacities in metallurgy, mechanical engineering and chemical engineering from advanced technical colleges. Some of the workshops were even able to export products. This shows that prospects for developing micro- and small metal works into solid engineering firms are not dim. The case of the Philippines underscores the importance of higher levels of technical capacities in the metalworks sub-sector, and the determination of firms compete in international markets.

It may finally be admitted that the review has not specifically made incisive coverage of studies that raise the frequently cited growth constraints facing SMEs in general: for instance, Agmas (2020) in a study of micro-metal and wood-working industries in Debre Markos Town in Ethiopia or Kulah (2016) on the challenges facing welding craftsmen in the urban areas in Ghana. The constraints identified include power interruptions, shortage of plots for a workshop, low technology and skill levels, limited sources of raw materials, management skills and good governance. Although they also inform on the basic constraints faced by metalworks MMEs, they do not raise specific upgrading issues as such.

Methodology

A desk review of published and unpublished documents preceded the planning and execution of the one-shot survey of SMEs in the metalworks sub-sector in Morogoro Municipality. The Municipality was selected as a case study since it was in one of the earlier cluster initiatives in the mid-2000s that included some of the small metal works establishments in the area (Mwamila and Temu 2006; Landa, 2015). As noted in the introduction, however, not all MMEs participate in the cluster initiatives. Purposive sampling was made of all wards with a relatively large number of metal manufacturing enterprises (MMEs). The number of all existing MMEs in each ward of the Morogoro Municipal Council (MMC) were listed with the assistance of the Municipal Trade Office and the support of Morogoro Engineering Cluster Initiatives leader to form a sampling frame. Given the available resources (time and finance), the study sampled at least 60% of wards. Thus, 18 wards out of 29 were purposively sampled by ranking the number of MMEs in each ward.[3] The sampled wards from the sampling frame (with ranked wards by number of MMEs) had at least 10 MMEs. All existing MMEs that met sampling criteria (being operational and having a premise for operation) in each ward were sampled. A total of 285 metal manufacturing enterprises were sampled from 18 wards with a total of 383 MMEs. A semi-structured questionnaire, which was defined in Kobo software, was administered to owners of MMEs using tabs by 6 trained enumerators after piloting it.[4] The questions aimed at eliciting insights on the determinants of innovation and the contribution of the cluster initiatives to SME upgrading.

The questionnaire sought information or data on key variables which include education, age, gender, main occupation, experience in business, and skills of MMEs owners. The characteristics of MMEs collected include registration, specialization, record keeping, technology used, innovation issues, size of enterprise in terms of employees and capital, access to credit, operational costs and sales, networking, and working environment.[5] A checklist was prepared to get information from key stakeholders, including Morogoro Engineering Cluster Initiatives leaders, MME group leaders and municipal officials. Some of the guiding questions in the checklist aimed at understanding the number and level of activities of MMEs and distribution in

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[3] The wards with highest and lowest numbers of active MMEs in the sampling frame were Kihonda (48 MMEs) and Kauzeni (4 MMEs) respectively. The sampling frame had 10 wards with 10 to 20 MMEs, 8 wards with 21 to 50 MMEs and 11 wards with less than 10 MMEs

[4] The survey questionnaire is not appended to this paper to minimize the size of the paper as it has nine pages; however, it is availed on request and submitted to journal as supplementary material.

[5] In classifying Micro and Small and Medium Enterprises (MSMEs), number of workers is used as an indicator of enterprise size. In Tanzania the cut-off points are 1-4 workers (micro) and 4-49 workers (small) (URT 2003); 1-9 workers for 'micro' enterprises in the Philippines (MRDC 2014); and 1-5 workers for 'micro' and 6-30 workers for 'small' firms in Ethiopia (Agmas, 2020).

Morogoro, specifically at the ward level, to facilitate sampling. Other key questions that were included in the checklist were on the status of MMEs (size, level of formalisation, technology), trend, socio-economic contribution of MMEs, constraints and existing support to MMEs. Training of enumerators was conducted and all instruments for data collection were piloted before the main fieldwork.

The contextual and descriptive analyses are complemented by quantitative analyses to determine the relative strength of factors determining enterprise upgrading. Subjective assessments observe the firm-owner's assessment of the firm; business performance (output, sales, access, cost and quality of inputs, policy facilitation or constraints) and inter-firm linkages. Objective assessment employs financial data (sales, profits, market share) and non-financial indicators, mainly employment growth. Thus, two modelling approaches, i.e., the probit and multiple linear regression model using ordinary least squares (OLS) estimation, are used to perform the quantitative analyses for the robustness check.

Probit Model

In analysing the determinants of innovation of MMEs through subjective assessment, the enterprise is assessed in terms of its capacity to design a product per customer's preferred specifications and make design modifications in order to attract new customers. Given that the dependent variable (innovation) is a binary response that only takes the values 0 or 1; the probit model is considered to be the best model when examining the factors that facilitate the upgrading of the MMEs. Probit models are binary classification models whereby the dependent variable is binary, which assumes that the error term has a standard normal distribution, is independently distributed and estimated by the Maximum Likelihood Estimation (MLE) procedure. By using MLE, the probit model can identify factors associated with the likelihood of an enterprise to upgrade/innovate.

First, we construct a binary variable to proxy innovation. Specifically, innovation takes two possible values, 1 if an enterprise (MME) innovates or 0 otherwise. We assume that the ability to innovate depends on an underlying but unobservable (latent) variable that determines the observed outcome which is influenced by a set of independent variables such that:

$$Y_i^* = X_i^* \beta + \varepsilon_i \qquad (1)$$

Where:

Y_i^* is an unobserved (latent) innovation tendency for enterprise (MME) i

X_i^* is a vector of explanatory variables (like the owner of the enterprise's personal characteristics such as gender, age, education level, household size) for MME i

β is a vector of estimated coefficients for explanatory variables.

ε_i is a random error term (assumed to follow a standard normal distribution, i.e., $\varepsilon_i \sim N(0,1)$)

i denotes a specific MME that was observed or analysed in the sample, i.e., i = 1, 2, 3, …, n

In the probit model, we do not observe Y_i^* instead we observe,

$$Y_i = 1 \ if \ Y_i^* > 0$$
$$Y_i = 0 \ if \ Y_i^* \leq 0 \qquad (2)$$

Where Y_i is observed innovation outcome (1 or 0) of MME i .

Therefore, the probability that an event occurs, in our case where an enterprise can design per customer need or make design modifications, is given by:

$$P(Y_i = 1|X_i^*) = P(Y_i^* > 0|X_i^*)$$
$$= P(X_i^*\beta + \mu_i > 0|X_i^*)$$
$$= P(\mu_i > -X_i^*\beta) \quad (3)$$

Since the probit model assumes the errors are independently distributed, then

$$P(Y_i = 1|X_i^*) = F(X_i^*\beta) \quad (4)$$

The function *F* represents the standard normal cumulative distribution function, which is used to convert the estimated scores from the model into probabilities of participation. The term $X_i^*\beta$ captures the combined effect of the explanatory variables on the likelihood of participation.

Ordinary Least Squares (OLS) Regression Model

The analysis of the determinants of innovation of MMEs is also conducted through objective assessment by using non-financial indicators, specifically the level of employment or employment growth. The indicators based on financial data, such as sales, profits and capital, change with the time value of money. They may not always reflect trends in the size of the firm (JICA, 2017). In developing countries, most SMEs do not properly keep books of (audited) accounts. Thus, the number of employees becomes a preferred indicator of the time path of enterprise growth. The multiple linear regression analysis using OLS estimation is employed to examine the factors that affect the innovation of MMEs given the fact that the dependent variable is a continuous number (number of employees).

The number of employees, which is assumed to be a linear and continuous variable, is used as a proxy for enterprise growth (dependent variable). This paper acknowledges the endogeneity problem that may arise using the firm size as a proxy for firm growth due to reverse causality, and it is advised to use panel data in that situation (Cameroon & Trivedi, 2010; Wooldridge, 2012). However, in the absence of panel data and other variables, the number of firm employees (firm size), which is easily captured, is used as a proxy of firm growth at the point in time, with the assumption that the cost of employees reflects the actual labour market value, especially in labour intensive firms. In this case, the OLS method is an appropriate estimation technique and is specified as:

$$Y_i = \alpha + X_i\beta + \varepsilon_i \quad (5)$$

Where:

Y_i is the number of people employed by the metal manufacturing enterprise i;

α is the intercept (constant term)

X_i is a vector of the explanatory (independent) variables which include the owner of the enterprise personal characteristics (gender, age, education level, household size), occupation,

work experience, enterprise registration, location, formal skills, technology use, membership in the metal cluster and work as a group, for enterprise i and
ε_i is the stochastic error term capturing the unobservable influence of enterprise growth.
i represents each individual enterprise that was observed in the sample, i.e., i = 1, 2, 3, …, n.

Description of Variables
Table 2 summarizes the variables that were included in both Probit and OLS regression models. It provides the definition and measurement of each variable.

Table 2: Variable Definition and Measurement

Variable	Label	Measurement
Dependent variable		
Enterprise ability to design or make modifications as per customer	Innovation	1= Yes ; 0= otherwise
Firm size (number of enterprise employees)	Employee	Continuous variable(number)
Independent variable		
Gender of the owner of the enterprise	Gender	1=Male; 0=Female
Age of the owner of the enterprise	Age	Continuous variable (years)
Education level of the owner of the enterprise	Education	Continuous variable(years)
Household size (#)	Hsize	Continuous variable
Main occupation	Occupation	1= metal manufacturing enterprise; 0=otherwise
Work experience	Experience	Years
Enterprise registration	Registration	1=Yes; 0=No
Enterprise location	Location	1= Urban; 0= Peri-urban
Formal skills	Skills	1= yes; 0= otherwise
Technology use	Technology	1= Modern; 0= Local
Membership of Cluster/Association	Membership	1=Yes; 0= otherwise
Work as a group	Group	1=Yes; 0=otherwise

Findings and Discussion
Summary Statistics of Key Variables
Table 3 presents the summary statistics of the key variables that were used for analysis. The findings indicate that the age of the sampled MME owners on average was 39 years. This is an active age to operate and manage MMEs. Almost all (99.6%) owners of MMEs were males, implying male dominance in this kind of enterprise (metal manufacturing enterprises). The nature of work is male-biased and not favourable to women. The enterprises are so small that they do not even have a formal and fully-furnished office to require the engagement of office assistants, such as a clerk or an accountant. The average household size (Hsize) of owners of MMEs was 4.4, which is close to the official national household size (4.3 persons per household) in Tanzania according to the 2022 National Population and Housing Census (URT, 2024: 35). The results further show that the average number of years of education of the owners of MMEs was 9.2,

which is higher than 'Form I' of secondary school. Thus, the owners of MMEs had at least a secondary education.

Table 3: Descriptive statistics

Descriptive statistics for continuous variables					
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Age	285	39.291	11.35	19	80
Hsize	255	4.365	1.975	1	11
Education	285	9.193	3.277	0	20
Experience	282	9.539	8.27	1	45
Firm size (Employees)	284	1.803	2.19	0	15
Descriptive statistics for Binary variables*					
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Gender (Male=1)	285	0.996	0.059	0	1
Main occupation (Metal manufacturing enterprise=1)	285	0.919	0.273	0	1
Registration (Yes=1)	283	0.258	0.438	0	1
Location (Urban=1)	283	0.823	0.382	0	1
Skills (Formal=1)	284	0.239	0.427	0	1
Innovation (Yes=1)	285	0.937	0.244	0	1
Group (Yes=1)	285	0.095	0.293	0	1
Membership (Yes=1)	284	0.088	0.284	0	1
Technology (Modern=1)	285	0.832	0.375	0	1
Working environment (Yes=1)	280	0.507	0.501	0	1
Government regulations and policies (Yes=1)	283	0.534	0.5	0	1

* Descriptive statistics for Binary variables are expressed in percent by multiplying each mean by 100.
Source: Authors' computation based on NPS data – Wave 4 (2014/15) and Wave 5 (2019/20)

The statistics indicate that metalworking was the main occupation (91.9%) and the metal manufacturing enterprises were mainly located in urban areas (82.3%). The high demand for metalworks products in urban areas is associated with the rapid expansion of the construction of new settlements. Notably, electricity, which is one of the main inputs in metalworking enterprises, is available and reliable in urban areas. Only 25.8% of the sampled MMEs were registered, indicating that most enterprises operate informally, concurring with the results of Salam *et al.* (2018). With regard to formal skills, descriptive statistics show that the sample average of MMEs owners with skills accounted for only 23.9%. Most of the MMEs owners do not have formal skills from VETA or similar institutions, as was found by Agmas (2020) and Belis (2011) in Ethiopia and Campos, Goldstein, and McKenzie (2023) in Malawi. Only 9.5 and 8.8% of MMEs were members of groups and cluster/association of metal-related works, respectively. This is evidence of low networking among metalwork enterprises. 83.2% of the MMEs used modern technology and 93.7% had some level of innovation. Modern technology was related to the use of more efficient machines, such as welding and grinding machines. Innovation meant the ability to design products to suit customers' preferences and make modifications in order to win new customers. But the average firm size in terms of number of employees was 2 employees per MME (with a minimum of 0 and a maximum of 15 employees).

More than half of MMEs (i.e., 50.7%) considered the working environment conducive, even though most considered the working space limited. 53.4% considered that the existing government regulations and policies were clear. Many, however, noted concerns about the manner and details of how public policies were enforced and biased attention in favour of 'larger' enterprises when it comes to technical and business development support services.

Micro-metalworks Characteristics

Specialization of MMEs

Figure 1 shows that 64.9% of the sampled MMEs comprise enterprises that make house metal construction materials such as aluminium windows and doors, and fabrication of security metal guard (grills). This group is followed by enterprises that make various types of products with skills such as welding and painting (17.2%). Metal fabrication and machineries, a 'more advanced' group in metalworks, comprises 4.2% of all enterprises.

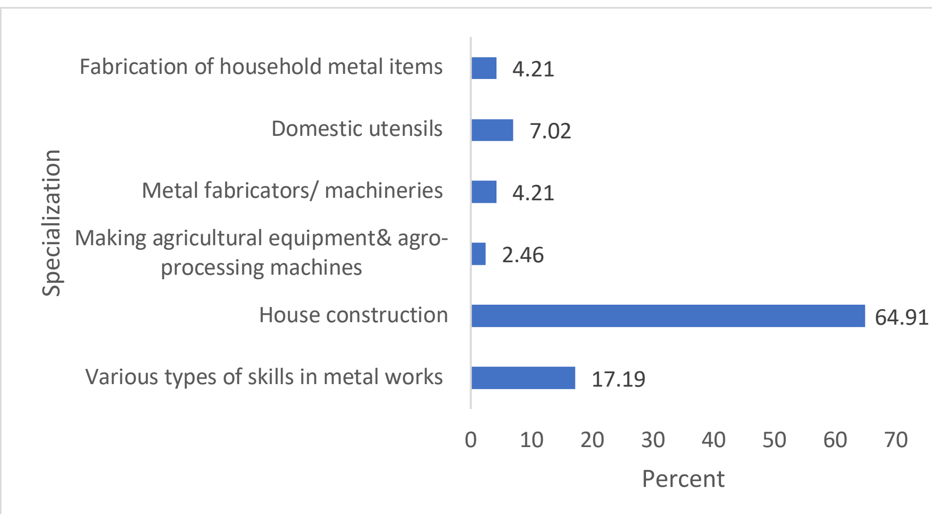

Figure 1: Distribution of Metalworks Enterprises by Specialisation
Source: Authors' computation based on NPS data – Wave 4 (2014/15) and Wave 5 (2019/20)

The relationship between the specialization of MMEs and their registration status (Table 4) shows that MMEs which make agricultural equipment and agro-processing machines form the largest of enterprises that are registered (85.7%), followed by house construction such as aluminium windows and doors (27.3%), metal fabricators/machineries (25%) and fabrication of household metal items (25%).

Table 4: Metal Enterprise Specialization and Registration Status

Metal Enterprise Specialization	**Metal manufacturing enterprise registration**	
	No (Percent)	**Yes (Percent)**
Various types of skills in metalworks	79.59	20.41

House construction	72.68	27.32
Making agricultural equipment and agro-processing machines	14.29	85.71
Metal fabricators/ machineries	75	25
Domestic utensils	95	5
Fabrication of household metal items	75	25
Total	**210(74.2)**	**73(25.8)**

Source: Authors' computation based on NPS data – Wave 4 (2014/15) and Wave 5 (2019/20)

Table 5 shows the relationship between the type of technology used by MMEs and their registration status. As much as 16.4% of registered MMEs use modern technology as opposed to 8.1% of unregistered MMEs. Conversely, high use of local technology (20.5%) is observed within unregistered MMEs as opposed to within registered MMEs (5.5%). This implies that registration or formalization encourages the use of modern technology (Zhao *et al*., 2022) which is likely to contribute to innovation.

Table 5: Kind of Technology Used by Enterprises and Registration Status

Kind of technology used by the enterprise	**Metal manufacturing enterprise registration**		
	No (%)	Yes (%)	Total*
Local	20.48	5.48	47(16.61)
Modern	8.1	16.44	29(10.25)
Both local and modern	71.43	78.08	207(73.14)
Total observation	**210**	**73**	**284 (100.0)**

* The number in brackets indicates percent.

Source: Authors' computation based on NPS data – Wave 4 (2014/15) and Wave 5 (2019/20)

Type of ownership of MMEs

Figure 2 shows that sole proprietorship/individual ownership was the leading form of ownership (82%) followed by partnership (14%). A sole proprietorship is the simplest way to organize and run a business, as one sole owner is responsible for the operation of the business. This ownership of microenterprise characteristic is common in the informal sector in developing countries (UNCTAD, 2001; Salam *et al.* 2018; ILO 2022).

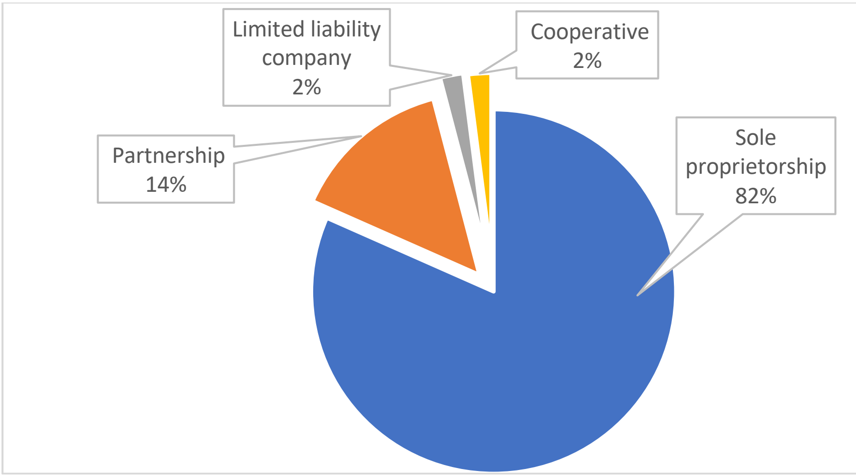

Figure 2: Distribution of Ownership of the Company.

Source: Authors' computation based on NPS data – Wave 4 (2014/15) and Wave 5 (2019/20)

Sources of skills

The findings in Figure 3 show that most of the MME owners acquired skills through learning informally, as 50% of them acquired skills from friends, relatives and other firms, whereas 23.9% acquired skills through formal vocational training. These findings concur with those of Thomas (2011) and Ubele and Okwelle (2020) who found a larger proportion of operators of SMEs acquire skills informally. These findings suggest a need to extend formal vocational training programmes to the owners of MMEs while also leveraging informal learning channels to support these efforts.

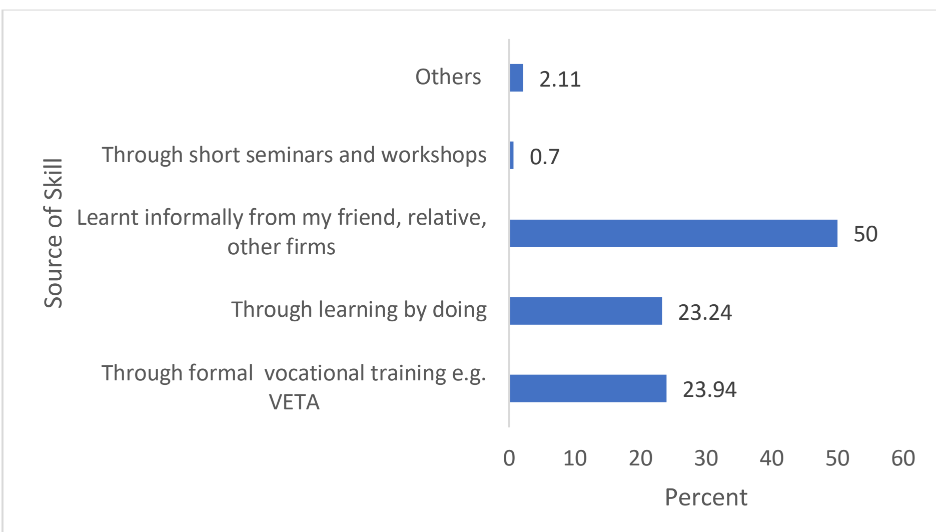

Figure 3: Distribution of Sources of Skills to Operate Metal Manufacturing Enterprises

Source: Authors' computation based on NPS data – Wave 4 (2014/15) and Wave 5 (2019/20)

Econometric Results

Before estimation, appropriate tests of the model fitness were carried out. The model used in the study had R-squared value of 0.236, indicating that the regressors have statistically significant coefficients with the expected signs. The Breusch-Pagan test revealed evidence of heteroskedasticity in the regression model using the fitted values of firm size, which was addressed by using robust standard errors in the regression model. The VIF values indicated that there was no significant issue of multicollinearity among the variables in the model.

Probit Model Results

Table 6 presents both probit regression and marginal effects results from probit model analysis on determinants of innovation or growth of MMEs. Probit regression results only present the direction of association between dependent and explanatory variables, while the marginal effects determine the relative effectiveness and magnitude of a unit change in the value of an explanatory variable on the innovation/growth of metalworking enterprises. The results indicate that the household size (Hsize) of the owner has a significant negative influence on the probability of a firm innovating at 5% level, whereas age of the owner, education level, working environment, and government regulations and policies have a significant positive impact at 5% level.

Table 6: Probit Regression and Marginal Effects Results

`	**(Probit Model)**	**(Marginal Effect)**
VARIABLES	**Innovation**	**Innovation**
Firm size	0.0338	0.00337
	(0.0680)	(0.00686)
Registration	0.341	0.0340
	(0.430)	(0.0427)
Age	0.0425**	0.00424**
	(0.0187)	(0.00195)
Education	0.111*	0.0110**
	(0.0576)	(0.00555)
Hsize	-0.178**	-0.0177**
	(0.0744)	(0.00767)
Technology	-0.730	-0.0728
	(0.465)	(0.0479)
Experience	-0.0315	-0.00314
	(0.0228)	(0.00231)
Working environment	1.037**	0.103**
	(0.434)	(0.0460)
Government regulation	0.938***	0.0935**
	(0.350)	(0.0386)
Constant	0.0844	
	(0.904)	
Observations	**244**	**244**

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' estimation based on NPS data – Wave 4 (2014/15) and Wave 5 (2019/20)

The probit model results imply that owners of MMEs with larger households may face more constraints when investing in innovative activities. Households with more than one member have a low probability of innovating by 0.057 units. The results concur with those of Kufenko, Geloso and Prettner (2018), who found that entrepreneurs with large household sizes have low savings for investment due to high dependency and thus much of the household income is spent on consumption. Conversely, older and more educated owners are more likely to engage in innovative activities. The positive effect of age and education on innovation of MMEs is attributed to accumulated knowledge and experience which are crucial factors for innovation as they help entrepreneurs make the right decisions (Agmas, 2020; Venatius *et al.,* 2021; Campos *et al*., 2023). However, some studies have shown that the age of the owner of MME negatively affects innovation because of risk-averse behaviour, which is inversely related to age, as innovation is considered a risky venture (Araar *et al*., 2019; Cid-Aranda and Lopez-Iturriaga, 2023). Regarding the importance of education, entrepreneurs with lower education (below lower secondary school, i.e., below Form I) admitted during the discussion that their lower education is a cause for their being slow in catching up with counterparts who had higher levels of education.

In addition, a good working environment – enterprise premises and government regulations and policies underpin and support the efforts of entrepreneurs to become more innovative and competitive (Ramanathan *et al*., 2017; Quak, 2019; Agmas, 2020; Zhao, Yi, Zhan, and Guo, 2022). Nearly all MMEs owners admitted that they were aware of the safety, health and environmental requirements at workplaces during the discussion. On their part, government leadership at the ward level feels their duty is to oversee compliance. The owners of MMEs expressed willingness to comply with state or local government by-laws whenever they can afford the required gear (e.g. fire extinguishers, protective glasses for welders, gloves). The findings of the current study portray Reeg (2013) 'onion' model of determinants of innovation of enterprises. However, technology adoption had a negative and insignificant relationship with the innovation of firms. This inverse relationship between technology and innovation may seem counterintuitive, but it may happen because of technology adoption and the innovation process misalignment and/or poor technology implementation. The negative relationship between technology adoption and innovation of the firms has been reported by other studies, such as Ryu and Lee (2015) in Korea and Zhang and Aumeboonsuke (2022) in China.

OLS Regression Results

Table 7 presents multiple linear regression results using OLS estimation. The results show that registration of enterprises, use of modern technology, enterprise facing market competition and enterprises being a member of the cluster have a positive and significant effect on enterprise growth at 1% level, while the experience of the enterprise owner has a significant effect at 10% level. Specifically, the results show that registered metalworks enterprises have a better chance of growing by an average of 1.254 units compared to unregistered enterprises. Enterprise registration increases the confidence of owners and expands the opportunities for enterprises to secure loans from formal financial institutions and tenders from various sources, including the government, NGOs, and private institutions, as noted by Addisu (2024) in Ethiopia and Lambert and Deyganto (2023) in Africa. The results also indicate a positive relationship between the use of modern technology and the growth of MMEs, with a significant effect at the 1% level of significance. Using modern technology in metalworks enterprises leads to an average growth of 0.904 units higher than enterprises that do not utilize modern technology. The results of this paper concur with those of Agmas (2020) and Haruna (2023) who found a positive impact of the use of improved technology and formalization of enterprises on their performance in Ethiopia and Nigeria respectively.

Table 7: OLS Regression Results

VARIABLES	**(OLS estimation)**
	Firm size
Occupation	0.483
	(0.391)
Registration	1.254***
	(0.362)
Skills	-0.284
	(0.305)
Technology	0.904***
	(0.335)
Age	-0.0211
	(0.0170)
Education	0.0736
	(0.0571)
Hsize	0.0452
	(0.0700)
Experience	0.0321*
	(0.0181)
Government regulation and policies	-0.426
	(0.312)
Business competition	1.126***
	(0.327)
Association	1.791***
	(0.557)
Working environment	-0.200
	(0.320)
Innovation	-0.00761
	(0.459)
Constant	-0.827
	(1.070)
Observations	241
R-squared	0.230

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' estimation based on NPS data – Wave 4 (2014/15) and Wave 5 (2019/20)

The results further reveal that experienced metalworks enterprise owners increase firm growth by 0.0321 units. This implies that the knowledge and skills acquired through experience contribute to improved decision-making, managerial abilities and understanding of industry (Ramanathan *et al*., 2017; Venatius *et al*., 2021; Addisu, 2024). Furthermore, membership in an association positively affects innovation and growth with a significant effect at the 1% level of significance.

Being a member of a group or an association increases growth by 1.791 units. The beneficial effects of networking of SMEs are also confirmed by Narcizo and Cardoso (2012) and Quak (2019). Nevertheless, the OLS model in Table 7 explains about 24% of the variation in firm growth, as indicated by the R-squared (coefficient of determination) of 0.236, suggesting limited explanatory power. On one hand, this implies that there might be other important factors (omitted variable bias) or the presence of unobserved firm characteristics that might also influence enterprise growth. On the other hand, the limited explanatory power (low R^2) is due to the inherent nature of the data, especially in social sciences associated with unpredictable human behaviour. To address the problems, future studies should consider adding more relevant variables and, more importantly, use panel data for analysis.

Conclusion and Policy Implications

This paper has examined the factors (entrepreneur, enterprise and environment attributes) that influence innovation-led 'enterprise upgrading' of micro-manufacturing enterprises (MMEs) in the metalworks sub-sector in Tanzania using a mixed approach and rigorous analysis. Most of the MMEs are at the bottom of the pack (that is, being 'micro', employing an average of 2 employees (with a range of 0 to 15 employees). The majority of them are not registered (73.7%), that is, they are informal and unable to afford modern technologies. Further, the age of the owner of MMEs, education level, working environment, and government regulations and policies have a positive and significant influence on innovation in enterprises. Correspondingly, the use of modern technology, experience of enterprise owner, market competition and being a member of an association have a positive and significant effect on the growth of metal manufacturing enterprises. The findings of this study explain well Reeg (2013) 'onion' model of determinants of innovation of enterprises.

Therefore, any initiatives that support and promote the formalisation of MMEs, provide skills or formal technical training to enterprise owners and make secondary education basic are pertinent to enhance innovation-led MMEs upgrading in Tanzania and other developing countries. However, friendly and supportive government policies and regulations are paramount for other determinants of innovation and growth (upgrading) of metal MMEs. This paper further recommends the use of panel data in future studies that may address endogeneity problems. More active roles by experts from core fields of engineering and others at higher levels will be critical in charting a pathway for small metalworking enterprises.

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