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Yessica C.Y. Chung*

Abstract

Using an enterprise-level dataset collected from 234 workshops located in the furniture cluster of the city of Arusha, Tanzania, this paper investigates the mechanisms of technical knowledge exchange that take place in clusters. A knowledge exchange link is defined as any two clustering entrepreneurs who perform similar manufacturing techniques in the production process. The results show that the strength of the ethnic networks of producers has positive effects on acquisition of manufacturing techniques, particularly in skills such as wood-joining, which are mainly influenced by a producer's own skills rather than production facilities. Using dyadic data analysis, this paper further finds that two producers from the same ethnic minority are more likely to exhibit the same manufacturing techniques compared with two producers from the same ethnic majority. These findings suggest that ethnic networks facilitate knowledge exchange in an industrial cluster, but that this positive externality of the ethnic network effect only takes place in small-sized ethnic groups, and only to the extent that sophisticated facilities are not essential in the knowledge learning processes.

Keywords: ethnic networks, knowledge learning, industrial cluster, Africa

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1. Introduction

Continuous acquisition of knowledge and innovation is crucial for the success of firms. Thus, one of the economic advantages attracting Small- and Micro-scale Enterprises (SMEs) to locate in industrial clusters is the knowledge spillover effect (Marshall 1920; Porter 1990; Kelly and Hageman 1999; Sonobe and Otsuka 2006). Knowledge spillover, which essentially means the informal benefit derived from innovations and technological improvements by other firms, is thought to take place through various channels including FDI, partner companies, research institutions, and interpersonal networks (Swenson 2007; Keller 2002; Saxenian 1994). In a naturally formed cluster without public-sector intervention, personal networks such as friendship and ethnic groups could be crucial channels of technical knowledge flows.

Due to its intangible nature, it is difficult for technical knowledge to be transmitted across firms without direct mutual interaction. In particular, African SMEs usually learn through trial and error or by imitation. In this context, entrepreneurs' interpersonal networks may serve as the key driver of knowledge acquisition. There is a rich literature that focuses on knowledge transmission within industrial clusters (Paci and Usai 1999 for European cases; Kelly and Hageman 1999 for the USA), but the significance of interpersonal ties is seldom observed. In practice, interpersonal ties may be more important for knowledge learning than tangible commitments (e.g., patents and commercial contracts) between clustering enterprises. Neglecting interpersonal ties will prevent us from explaining why some clustering entrepreneurs are able to gain knowledge spillovers more often and faster than others, and why it is difficult for some technologies to be practiced and diffused, especially in less developed countries. This paper will attempt to contribute to the study of clusters by focusing on the impact of ethnic networks on technology learning in Africa.

This paper uses a survey[1] dataset collected in a furniture cluster comprising five geographically distinct sub-clusters located in the city of Arusha, Tanzania, the features of which included the ethnic composition of entrepreneurs.[2] The explicit focus of this paper is on the role of ethnic networks on the technical knowledge exchange process in the industrial cluster. Empirical results obtained from 234 furniture producers show that the acquisition of skillful wood-joining techniques is positively associated with the strength of ethnic networks of furniture producers; if producers have more industrial peers from their ethnic group (defined as speaking the same mother tongue) located within a 1 km of radius of the furniture workshop, they are more capable in terms of manufacturing techniques. Furthermore, using dyadic data analysis, this paper explores whether two enterprises sharing the same cultural background are more likely to exhibit the same manufacturing techniques; in other words, if knowledge exchange is more active within an ethnic group than across ethnic groups. This hypothesis is supported, but the results also show that active knowledge exchange only takes place in ethnic minority groups rather than in the ethnic majority. In addition, technical knowledge exchange occurs only to the extent that there is little necessity for the use of advanced equipment in the process.

The remainder of the paper is organized as follows. Section 2 documents the industrial sub-clusters and the surveyed industrial cluster: the furniture industrial cluster in the city of Arusha, Tanzania. Section 3 presents knowledge learning and exchange in the cluster, and also develops empirical hypotheses regarding technical knowledge exchange. Section 4 introduces empirical methodologies and presents descriptive statistics. Section 5 reports empirical results. Section 6 presents conclusions and provides policy suggestions based on the findings.

1. The survey was funded and carried out by the JBIC Institute (now JICA-RI).
2. The formation of this cluster has been explored by Muto et al. (2009) and their findings show that ethnic networks predict the formation of industrial clusters, which is rarely the case in non-African countries. However, the mechanism underlying the relation of ethnic networks to business operations is unexplored.

2. Industrial clusters and knowledge spillovers

In the spatial economics literature, the term "industrial cluster" refers to a geographical concentration of a large group of interconnected companies and institutions in related industries in a particular location (Swann et al. 1988; Porter 1990; Sonobe and Otsuka 2006). Two types of industrial clusters, those generated naturally and those generated as led by policy, are extensively discussed in the geographic economics literature. Spontaneously formed clusters usually arise in areas where the industry has natural cost advantages (Carlton 1983; Bartik 1985; Krugman 1991; Henderson 1997; Ellison and Glaeser 1997, 1999). This type of cluster is usually observed in less developed countries or in the rural areas of developed countries. According to the literature, the development pattern of industrial clusters follows three phases: initiation, quantity expansion, and quality improvement. In the initiation phase, industrial participants produce a common simple product. As most participants are not yet equipped with specialized knowledge and skills in production, the product remains low-quality. As innovation rarely takes place in this phase, participants in the industry usually perform trial and error techniques or imitate rivals or foreign peers. A positive economic profit then attracts a swarm of newcomers into the industry. However, as the profit decreases with the number of industrial participants, entrepreneurs who are not innovative are easily eliminated from the market. Therefore, in order to survive in the industry, participants start to innovate new production methods, improve the quality of produced products, or change their management style to respond to market changes.

Although industrial clusters may differ in their core industry sectors, sizes, and structures of the horizontal and vertical value chains, their economic effects on poverty reduction, industrial development, and national economic growth are well confirmed in the spatial economics literature. In a seminal book, Marshall (1920) first pointed out that three main economic effects arise from an agglomeration economy; more recent researchers agree, and

confirm Marshall's views (David and Rosenbloom 1990; Krugman 1991; Kelly and Hageman 1999; Sonobe and Otsuka 2006). First, the knowledge spillover effect refers to followers' benefits from the innovations and technological improvements discovered by leaders. Small latecomer firms in industrial clusters can access frontier knowledge without making the same costly investments as leading firms, and eventually even catch up with leading firms through information exchange within the cluster. A second benefit is the specialization and division of labor among firms. A greater availability of specialized intermediate input suppliers and businesses can reduce transaction costs for firms in the cluster and further create job opportunities for local people. Third, firms can obtain skilled labor more easily than industrial peers that are not in the clusters. Advances in cluster-based economies will then lead to expansion in the national economy.

Another spatial agglomeration, which is initiated by ethnic units, is often observed in multiethnic countries. Ethnic groups tend to dwell in certain areas, orchestrating events together, and some even develop business relationships (such as in Chinatowns). As verified by Dustmann and Preston (2001), hostile attitudes and intolerance on the part of the ethnic majority toward ethnic minority groups result in different economic behavior and living distance between each group. Contrary to a high risk of doing business with strangers, there is a higher level of trust and less conflict within intra-group contracts. In addition, sharing the same culture and language within an ethnic group enables members of the group to easily overcome information barriers and therefore reduce transaction costs. Such positive externalities of ethnic networks can be observed in industrial clusters as well. The first established and the most well-known agglomeration economy in China, the Shenzhen Special Economic Zone, was mostly initiated by Hong Kong and Taiwanese entrepreneurs in the early 1980s, when China remained a closed economy. Liang (1999) pointed out that sharing a common language, culture, and traditions with China enables Hong Kong companies and Taiwanese companies to access the Chinese market.

Seeking out alternatives for mutual help through partnerships with "natural groups," such as family, relatives, clans, and tribes, is more evident when public deliveries are poor and the institutional system does not function well, such as is observed in African countries.[3] Greif (1993) demonstrated this phenomenon by modeling the coalition among ethnically Jewish Maghribi traders in the western Mediterranean. He pointed out that agency relations (between merchants and agents) were governed by a reputation-based trust mechanism, so some information flowed only within the ethnic traders' group, particularly in a country without an effective legal system. Evidence of a significant personal networking effect on locational choice in industrial clusters in Africa is provided by Muto et al. (2009). They used the same dataset as the present paper and explored the determinants of the formation of the industrial cluster. They found that entrepreneurs tend to locate where there are high concentrations of industrial peers from their own ethnic groups. However, the mechanism underlying the ethnic effect within the industrial cluster remains unexplored in their paper. There are still few empirical analyses regarding individual knowledge exchange compared to those at the macro level,[4] mainly due to two challenges: first, it is difficult to identify an individual's exchange patterns; and second, the difficulty in distinguishing one knowledge transfer effect from another is formidable. A closer study of measuring knowledge learning in Africa by Conley and Udry (2010) overcame these difficulties by collecting the information neighborhoods of Ghana pineapple farmers, and the similarity in fertilizer usage between individual pineapple farmers and their information

3. Widner (1998) pointed out that commercial courts are much more corrupt in African countries than in other countries.

4. For example, numerous studies have investigated the technological transfer from advanced economies to less developed countries, in particular FDI-led knowledge spillovers from exporting countries to their destination countries (e.g., Swenson 2007; Todo and Miyamoto 2006; Keller 2002). Most studies view R&D expenditures and patent citations as the best indicators of technology diffusion (e.g., Keller 2002; AlAzzawi 2011; Jaffe, Trajtenberg, and Henderson 1993; Kelly and Hageman 1999; Jaffe and Trajtenberg 1999). However, these codified proxies for knowledge transfers/diffusions are not applicable to Africa where production units mostly belong to informal sectors and whose data are not coded according to the Standard Industrial Classification (SIC) code.

neighbors.[5] Following Conley and Udry (2010), this paper attempts to contribute to the small literature that explores technical knowledge exchange in clusters in African countries.

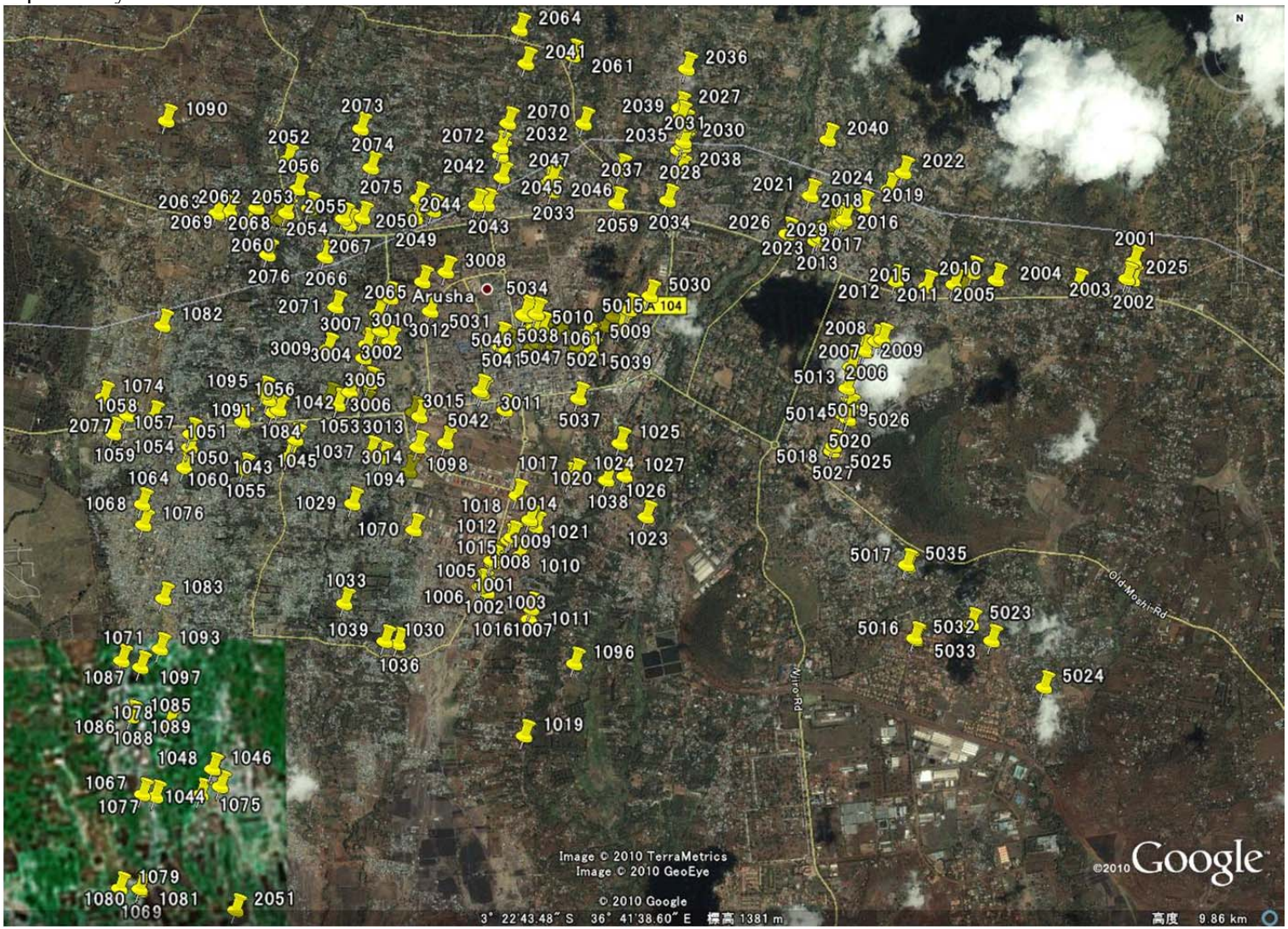
2.1 The furniture cluster in Arusha

The study area, the city of Arusha, is located in northern Tanzania, near the border with Kenya. The city is at the foot of Mount Meru, and the surrounding area includes Mount Kilimanjaro, the highest mountain on the African continent, and several famous parks including the Serengeti and Ngorongoro national safari parks. The natural environment provides its primary and tourism industries, as well as stimulating the growth of the local population, which was at least 1,200,000 people according to the 2002 census. The city is located at an elevation of 1,400 meters and has agreeable weather, with an average high temperature of 25 degrees and average relative humidity of 82%.

Furniture workshops are mostly located in five areas in Arusha: the Nairobi-Moshi Area, Industrial Area, Sokoine Area, Dodoma Road Area, and City Center Area. In total, the sample size comprises 234 enterprises. In terms of geographical distribution, there were 80 (34%) enterprises in the Nairobi-Moshi Area, 58 (25%) in the Dodoma Road Area, 38 (16%) in the Industrial Area, 31 (13%) in the Sokoine Road Area, and 27 (12%) in the City Centre Area. The geographical distribution is shown in Figure 1. These five apparently similar areas are distinctive in terms of geographical attributes. For example, workshops located in the Nairobi-Moshi area are located alongside the Nairobi-Moshi highway, while workshops located in the City Center Area are scattered and mixed with other industries.[6] Personal questionnaire-based interviews of furniture producers located in these five areas were conducted in 2007. As the survey is a census, the results of the analyses in this research will be able to capture the situation within the furniture industrial cluster of Arusha.

5. Their results show that farmers adjust their inputs to align with those of their information neighbors who have been successful in previous periods.
6. For details of the attributes of each area, see Muto et al. (2010).

Figure 1. Map of study area in Arusha



As shown in Figure 2, the number of furniture enterprises in Arusha has sharply increased since 2000, particularly during 2005-2007. Of the 234 enterprises in total, 105 enterprises[7] were established before and up to 2004, while the other 129 enterprises were started up during the 2005-2007 period. In interviews, producers stated that the dramatic increase was a result of the rising demand for furniture from the construction industry and the hotel industry, as well as increased population growth. To capture the change in the economic environment between the two periods, recall data for 2004 were constructed in the 2007 survey. Because the barrier to entry in the industry is low, most participants had neither learned relevant knowledge of furniture production in schools nor had experience in producing furniture. Formal learning sources are scarce and there is no FDI in the furniture industry in this area. Not surprisingly, the furniture industry in Arusha produces low-quality and low value-added goods. The three main products are beds, couches, and cupboards, respectively accounting for 70%, 36%, and 29% of the market share. Despite the low quality of the products produced, this industry is gradually expanding, as the economic activity in this area still remains at a low level, and targeted customers are mostly local people who have low consumption power and therefore are not particular about product design. Relating the furniture industry in Arusha to the three phases of industrial development presented in the literature, it is apparently still in a very early stage of industrial development.

7. Some may argue that the number 105 understates the actual number of enterprises that existed prior to 2004. Regarding this, according to the respondents, the rate of entry and exit for the industry in the area was not as significant as it has been in recent years. Thus, underestimates would not be a major concern in later empirical analyses.

Table 1. Furniture product and ethnic group

Ethnic Group	Members	N. of enterprises producing the product									
		Bed	Couch	Cupboard	Cabinet	Door	Table	Sofa	Dining Set	Coffee Table	Stool
Chagga	96	71	34	24	25	23	11	16	11	9	4
Pare	29	21	12	13	7	5	6	3	4	1	1
Sambaa	17	13	8	4	8	3	4	4	3		
Meru	11	4	3	1	3	2	3	3	3	2	1
Sukuma	8	6	3	5	1	2		2		2	
Arusha	7	6		2	1	1	1	1	1		
Maasai	7	3	1	1	4	5	2		3		
Nyaturu	7	2	5	4	2	4	3				
Hehe	4	4	2	1	1	3					
Haya	3	2			1		1			1	
Muha	3	3	1	2							
Nyamwezi	3	2	2	1			1				
Rangi	3	2	2	1			1	1			
Zaramo	3	3		1	2				1		
Zigua	3	1	1	1				1			
Iraki	3	3	1					1	1		
Digo	2			2					1	1	
Luo	2	2	1				2				
Makonde	2		1	1		2			1		
Makuwa	2	1	1		1			1			
Ngoni	2		1	1	1		2				
Nyiramba	2	2	1		1		1			1	
Yao	2	1		1	1	1		2			
Gogo	2	1	2		1	1			1		
Bisa	1	1	1	1							
Bondei	1	1			1	1					
Kaguru	1	1			1						
Mang'ati	1	1			1		1				
Nyakyusa	1	1			1		1				
Pogolo	1	1									1
Unguja	1	1							1		
Zanaki	1							1			
Gunya	1	1	1		1						
Lugune	1	1						1	1		
Nyisanzu	1	1		1			1				
Total	234	163	84	68	65	53	41	37	32	17	7

Source: Author's calculations based on the survey data.

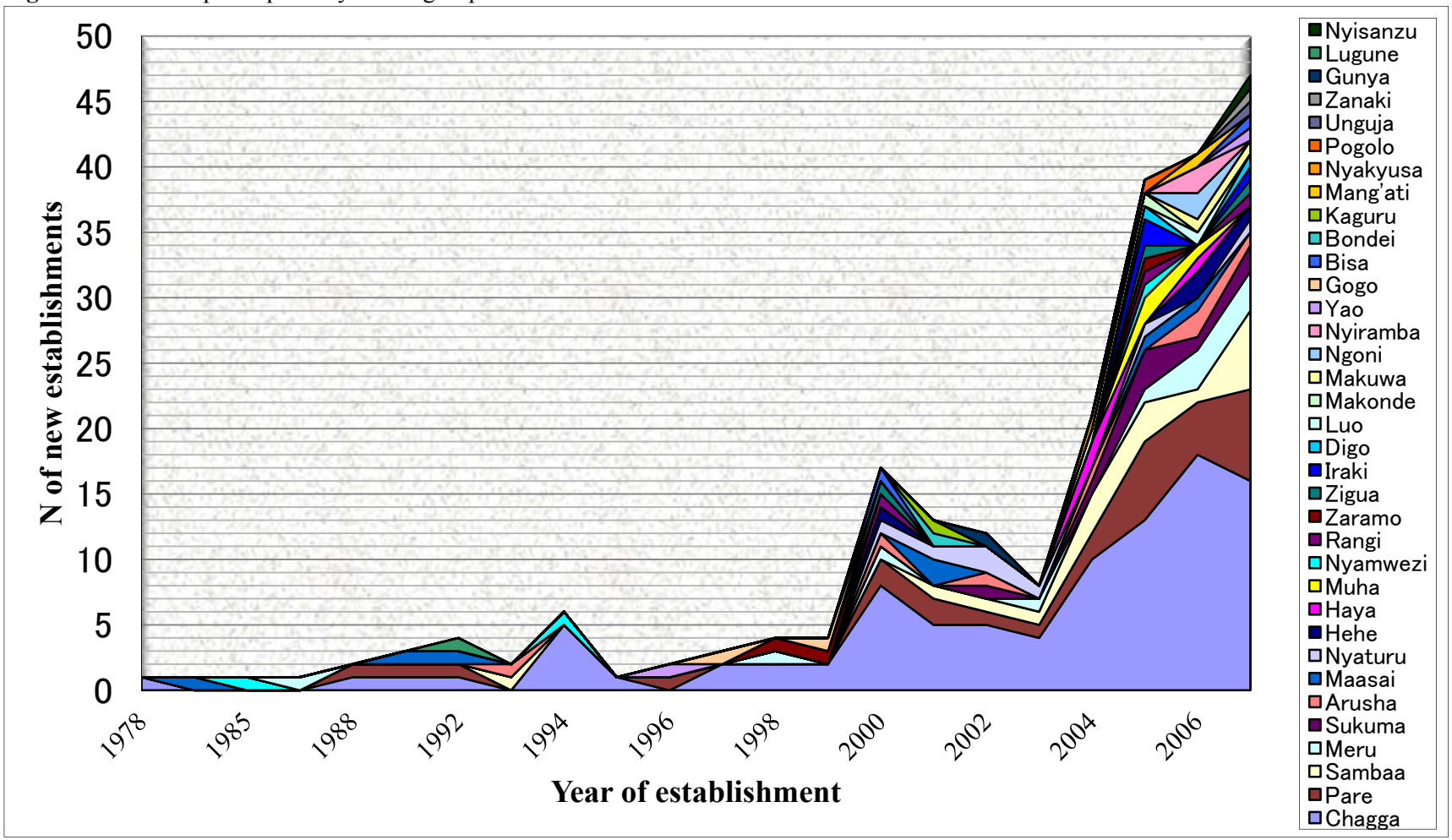
In addition to the significant increase in newcomers during 2005-2007, the furniture industry is characterized by the overrepresentation of the Chagga ethnic group. Overall, the industry comprises 35 ethnic groups. The number of entrepreneurs from each tribal group ranges between 1 and 96. The most prevalent tribe, the Chagga, is represented by 96 people, followed

by the Pare tribe (29 people), and the Sambaa (17 people).[8] Surprisingly, the Massai and Arusha ethnicities, which are the principal indigenous tribes in the Arusha region, each account for only 2.99% of the sample (7 people each). The largest tribe in Tanzania, the Sukuma tribe, accounts for 8%, representing 3.42% of the total of 234 entrepreneurs. A possible explanation for this limited representation of the majority tribes is that certain minority groups are over-represented in the industry. For example, as will be mentioned below, members of the Chagga ethnic group are renowned for their business skills among the other ethnicities, owing to their connections with advanced countries. As can be seen in Figure 2, the ethnic diversity of the furniture industry increases with the number of new workshops entering the industry, although the Chagga remain the ethnic majority.

Despite its ethnic dominance in the cluster, the Chagga are not the largest tribe in Arusha, or in the nation as a whole. Tanzania has more than 120 ethnic groups[9] and each ethnic group has its own language. The government currently does not have a racial segregation policy[10] and all tribes speak one of the official languages, either English or Swahili, in institutions. However, tribes that share the same language and customs are still apt to group together in particular areas. At times, the distinctive ethnic cultures result in ethnic communities and ethnic-based economies. The nomadic Maasai, for example, are well known as a typical tribe that live independently and preserve their traditional lifestyle and culture despite modern civilization. The third largest tribe, the Chagga, is mostly distributed around Mount Kilimanjaro and Mount Meru. The Chagga subsisted primarily on agriculture and are now known for their business skills.

8. Historically, the Pare people are culturally and geographically related to the Chagga people. Both are mainly located in the Kilimanjaro region, while the Sambaa tribe initially hailed from the Tanga region.
9. Of all ethnic groups, the Sukuma is the largest, accounting for an estimated 3.2 million members and representing 10-13% of the country's total population. Following the Sukuma, the second and third largest tribes are the Nyamwezi and the Chagga, respectively.
10. Tanzania was a German colony from the 1880s to 1919, and became a British colony from the end of World War I to 1961. During the colonial period, Germany established a rigid colonial racial hierarchy of Europeans, Asians, Arabs, and Africans in Tanzania, and Britain maintained the German policy of this racial hierarchy. Under this system, each group had its own schools, clubs, hospitals, and places of entertainment, and thus mixed racial activities were rare.

Figure 2. Furniture participants by ethnic group



Source: Author's calculations based on the survey data. (Retrospective data from author's survey.)

2.2 The furniture production process

One of the advantages of being located in an industrial cluster is the knowledge spillover effect from other industrial peers. However, empirical evidence of this remains scarce, mainly due to the lack of available data. As Marshall described knowledge diffusion in his seminal book: "The mysteries of trade become no mysteries; but are as it were in the air," and the paths of information diffusion are difficult to identify and fully track down. Nevertheless, in the main, learning outcomes are likely to be reflected in the production process, and ultimately on the value of finished products. For this reason, the furniture production process is illustrated below.

In general, the production process consists of procuring raw inputs (e.g., timber and iron), transportation and warehousing, intermediate processing (e.g., timber milling, metalworking, and tanning), assembling, transportation and warehousing, and marketing and retailing. However, as specialization and the division of labor in Arusha are yet not well developed, all processing activities in the furniture production process in the area, from timber seasoning, product design, component assembly, carving and polishing, and packing and delivery, through to product marketing, are carried out by only five entities: timber yards, furniture workshops, machining shops, metal materials shops, and cart shops. Most of these integrated entities are located in the clusters; in particular, machining shops are often observed near furniture workshops. Due to a shortage of cash, furniture workshops in the area employ a make-to-order production system approach; producers do not manufacture pieces of furniture unless they receive market orders with advance payment from customers. According to these orders, producers select and purchase timber at nearby timber yards or shops, and carry these raw materials to their workshops by cart. In the design process, some design patterns originate in the ideas of customers while some are drafted by the producers or come from overseas furniture magazines, which are mostly from Europe. Due to a shortage of capital, most producers do not possess machines for automation, and they outsource the production activities of timber cutting, milling, and shaping to machining shops. The processes following timber processing, from

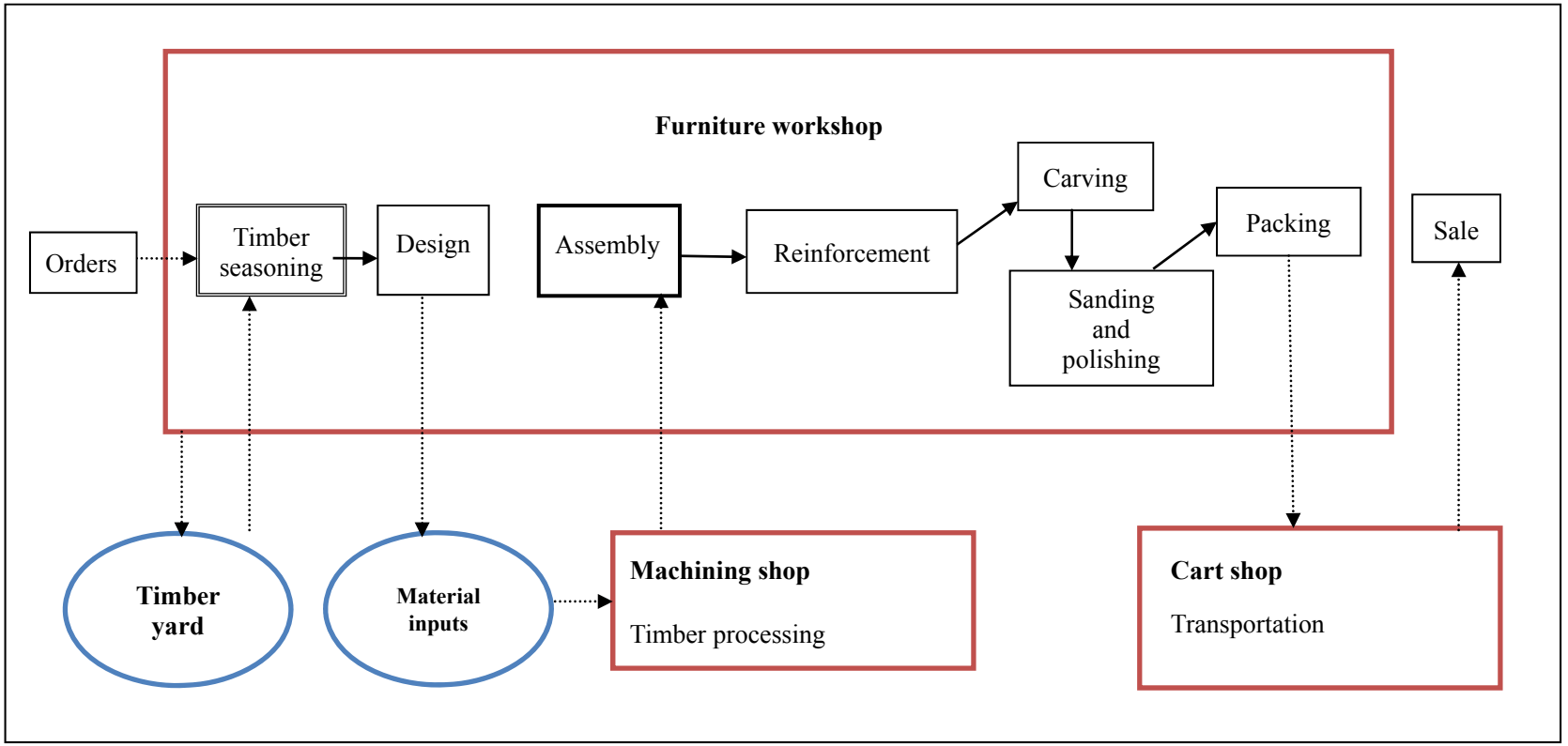
assembling to packing, are carried out at furniture workshops. Finally, most finished products are delivered by cart to customers and a few items of stock are displayed at workshops or showrooms.

In the production process, timber desiccation treatment and furniture assembly are the two crucial procedures. Wood is sensitively responsive to moisture, and its dimensions imperceptibly change as its moisture content changes, which can cause expansion or shrinkage that results in damage to the finished product. Therefore, too-humid or too-dry production environments should be the bane of furniture production, and a conditioned space for storing wooden materials is indispensible. However, a temperature controller is not an affordable device for Arusha furniture producers, and thus the timber seasoning process in the area is basically governed by the knowledge and experience of the producers. While some seasoned producers pay keen attention to this process to ensure that each piece of timber does not crack or warp, we also observed that quite a few producers stack timber in the corners of their workshops; all the worse, some producers even disperse unused timber outdoors without any waterproof sheeting or store timber in moldy places. A value of moisture content that is neither too low nor too high is good for wooden furniture. The optimization of the moisture content of timber varies with the temperature and humidity of its location. The Equilibrium Moisture Content (EMC) indicator is widely used as a measure of adequate moisture content of wooden furniture.[11] The optimum EMC of timber in Arusha is 2; a figure close to 2 indicates high product quality.

In addition to timber seasoning, the furniture assembly process makes an important contribution to the added value of a final product. Products joined without screws, nails, or glue, i.e., with mortise and tenon joints, are regarded as being high value-added items, but they are time-consuming and require skill, compared to butt joints in which pieces of wood are joined using screws, nails, or glue. Therefore, producers may not be capable of carrying out a mortise and tenon approach, or may not be willing to use these joints on low-price products.

11. We used the moisture meter HM52O (MOCO-2) to evaluate the moisture content of the main products of each interviewed workshop; these values are converted to the EMC indicator based on the temperature and humidity in Arusha.

Figure 3. Integrated production organization



Solid lines represent activities carried out by furniture workshops. Dotted lines represent outsourcing activities.

3. Knowledge learning and exchange

In this section, we tabulate education, past jobs, experience in training programs, product design and brands, and business use of mobile phones according to ethnicity and establishment year.

Table 2 uses two specifications: newcomer and incumbent producers. The former are the producers who started up furniture workshops during 2005-2007, and the latter are those who established workshops before and up to 2004. The figures presented in the second and third columns are calculated as a proportion of the total number in each group. The first and second sections of the table respectively provide comparisons of educational and occupational backgrounds between the two groups. Approximately 60% of entrepreneurs have primary education and 11% of entrepreneurs had work experience in furniture related industries,[12] but there are no differences between newcomer and incumbent producers (i.e., proportion tests are insignificant across educational and occupational spectrums). With regard to job training, it appears that, overall, furniture producers are rarely trained through formal programs.[13] However, we observe a significant difference between the two groups in terms of production training and marketing training; the proportion of producers acquiring formal training in the newcomer group (nearly 38%) is much lower than it is in the incumbent group (about 51%), with a z value of -2.06, significantly at a 5% p-value. In contrast, approximately 54% of newcomer producers obtained production skills through personal networks[14] while nearly 43% of incumbent producers did so, showing a proportion test of 1.73 with p-value of 0.01. In contrast to the results

12. Spin-offs are regarded as one of the important channels of knowledge transfers (Sonobe and Otsuka 2006), and in the *Furniture relevant* category of the *Past occupation* section, unreported data show that about 10% of producers in both the newcomer and incumbent categories were spin-offs from private or state-owned furniture factories.
13. This is primarily because these training programs are rarely implemented in the region; furniture producers are also unaware of the importance of this training for business as their businesses remain at an initial stage of industrial development.
14. However, we are not able to identify the nature of personal networks; these could be ethnic networks, relatives, family members, and even fraternal peers.

for production training, about 80% of producers have never received marketing training. Approximately 15% of newcomer producers acquired knowledge in marketing trough personal networks, while only 7% of incumbent producers did so; the proportion test value for the two groups is 1.95 and is statistically significant at 10%. Similar patterns are observed in business management and accounting training but with no significant differences between the two groups. On the other hand, we note quantitative differences between newcomer and incumbent producers in business practices including design patterns, brand names, and use of mobile phones. More than half of incumbent producers stated that they created designs by referring to catalogs[15] while nearly 52% of newcomer producers stated that they created furniture designs according to their own ideas. This may suggest that newcomer producers are more constrained in terms of social networks and knowledge learning sources than incumbent producers. About 18% of incumbent producers started branding their products in the start-up year, while only 7.8% of newcomers did so. Brand and store name can enhance the price effect (Rao and Monroe, 1989; Monroe and Krishnan, 1985) and reduce transaction costs; for example, consumers who are not familiar with alternative products may use store and brand name information (Monroe 1976). Thus, the significant and negative result of the proportion test indicates that incumbent producers are more innovative in terms of marketing their products. Compared to newcomer producers, incumbent producers tend to use mobile phones in their business. About 87% of producers used mobile phones for product promotion, while approximately 74% of newcomer producers did so.[16]

The comparisons of the ethnic majority and minority groups are presented in Table 3. In the educational background section, we observe few differences between these two groups, suggesting that the ethnic majority do not enjoy an educational privilege. In terms of past occupation, we note that about 60% of the ethnic majority had no work experience before their

15. According to respondents, these catalogs are mostly acquired from European countries.
16. An endogeneity problem between mobile phone use and the business scale of a workshop is debatable; richer and large-scale workshops are more likely to be able to purchase mobile phones. What is observed in the field is that mobile phones are common items in Arusha.

furniture business. Compared with nearly 41% for ethnic minorities, it is significantly high (p-value of 0.001 in the proportion test). Both groups exhibit a low proportion of producers having furniture related work experience; however, 46% of ethnic minority producers had worked in non-furniture industries, compared with 30% of the ethnic majority. In terms of training in business practices, members of the ethnic majority appear to be acquiring production skills through formal training, while those in ethnic minorities are likely to obtain their skills through personal networks, especially in production and accounting training.

It is apparent that a low proportion of furniture producers in the area were able to learn manufacturing techniques through formal education, past occupations, and formal training programs, regardless of their ethnicity and the inception time of their business. However, minority ethnic groups tend to learn through their kinship groups relatively more, while members of the ethnic majority receive relatively more training through formal apprenticeship programs. Incumbent producers in the cluster were more innovative than their newcomer peers in terms of marketing, i.e., branding their products, which is consistent with the literature that pioneer entrepreneurs are more innovative than newcomers.

In addition to product design and marketing, manufacturing techniques crucially determinate product value, particularly in terms of the EMC of timber and wood-joining techniques. The comprehensive data collected in the field for individual producers regarding these two production techniques and the data setting, which comprises a variety of minority ethnic groups and a dominant ethnic group, are well suited to examining the following hypotheses: (1) that entrepreneurs who have larger ethnic networks in a cluster gain more technical information and become more skilled in furniture production than those who have smaller ethnic networks; and (2) that information exchange is more likely to take place within an ethnic group than across ethnic groups.

Table 2. Newcomer vs. incumbent producers

	Newcomer	Incumbent	Proportion test
Highest qualification			
Under primary	2.33	1.9	0.23
Primary	66.67	57.14	1.5
Above and including ordinary	31.01	40.95	-1.58
Past occupation			
None	45.74	52.38	-1.01
Furniture relevant	11.63	11.43	0.05
Non-furniture	42.64	36.19	1
Production skills			
None	7.75	5.71	0.62
Informal learning	54.26	42.86	1.73*
Formal training	37.98	51.43	-2.06**
Marketing			
None	79.07	84.76	-1.12
Informal learning	14.73	6.67	1.95**
Formal training	6.2	8.57	-0.69
Business management			
None	83.72	86.67	-0.63
Informal learning	10.85	5.71	1.4
Formal training	5.43	7.62	-0.68
Accounting			
None	86.05	87.62	-0.35
Informal learning	9.3	4.76	1.33
Formal training	4.65	7.62	-0.95
How to create designs (%)			
Own	51.59	35.58	2.32**
From catalogs	35.71	50.96	-2.4**
From other workshops	3.17	3.85	-0.3
Customer specifications	9.52	9.62	-0.06
Brand name, years elapsed from establishment			
0	7.75	18.1	-2.39**
1	3.88	1.9	0.38
2	0	1.9	
More than two years	N.A	8.57	
No brand (up to 2007)	88.37	69.52	3.58***
Business use of mobile phones	73.64	86.67	-2.45**

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3. Ethnic minority vs. majority ethnic groups

	Minority	Majority	Proportion test
Highest qualification			
Under primary	2.9	1.04	0.97
Primary	62.32	62.5	-0.03
Above and including ordinary	34.78	36.46	-0.26
Past occupation			
None	40.58	60.42	-2.99***
Furniture related job	13.04	9.38	0.86
Non-furniture related job	46.38	30.21	2.49**
Production skills			
None	6.52	7.29	-0.23
Informal learning	53.62	42.71	1.64*
Formal training	39.86	50	-1.54
Marketing			
None	79.71	84.38	-0.91
Informal learning	13.04	8.33	1.13
Formal training	7.25	7.29	-0.01
Business management			
None	84.06	86.46	-0.51
Informal learning	10.87	5.21	1.52
Formal training	5.07	8.33	-1
Accounting			
None	85.51	88.54	-0.67
Informal learning	10.14	3.13	2.03**
Formal training	4.35	8.33	-1.26
How to create designs (%)			
Own	42.56	47.87	-0.8
From catalogs	41.18	44.68	-0.56
From other workshops	4.41	2.13	0.94
Customer specifications	11.76	5.32	1.68*
Brand name, years elapsed from establishment			
0	10.14	18.75	-1.89*
1	3.62	2.08	0.68
2	0	2.08	-1.7*
More than two years	4.36	3.13	0.48
No brand (up to 2007)	81.88	73.96	1.45
Business use of mobile phones	77.54	82.29	-0.89

Note: * significant at 10%; ** significant at 5%; *** significant at 1%.

4. Empirical methodologies and data

This section presents the methodologies and data for advancing the relationship between ethnic networks and technical knowledge exchange. Due to a lack of information on individual producers' social interactions with other furniture producers, such as those used in the work by Conley and Udry (2010), this paper uses a dyadic dataset to examine similarities in manufacturing techniques and how they relate to ethnic networks. Ideally, to investigate knowledge exchange between producers, data on social interactions between furniture producers should be collected. However, this research encountered difficulties in assembling such information. Instead, a dyadic regression as introduced below is used to compensate for this drawback. The latent variable, knowledge exchange y_{ij}^{*}, is as follows:

$$y_{ij}^{*} = \theta E_{ij} + \beta x_{ij} + e_{ij} \quad ,$$

where e_{ij} is an error term independent of explanatory variables E_{ij} and x_{ij}. The ethnicity variable E_{ij} takes a value of one if producers i and j are from the same ethnic group; otherwise it is zero. A set of control variables x_{ij} capture geographical distance[17] between workshops i and j, and characteristics of producers i and j. Instead of observing knowledge exchange, we observe only a count variable y_{ij} indicating the sign of y_{ij}^{*}. In practice, y_{ij} represents the similarity in technology between producers i and j:

$$y_{ij} = \begin{cases} 1 & if\ y_{ij}^{*} > 0 \\ 0 & if\ y_{ij}^{*} \leq 0 \end{cases} .$$

If knowledge exchange y_{ij}^{*} between producers i and j reaches a certain frequency, their manufacturing techniques y_{ij} are similar, and take a value of one; otherwise it is zero. The distribution of similarity in technology between two producers y_{ij} given x_{ij} is as follows:

17. In rural Tanzania, people do not register their addresses. The location of an enterprise is identified by global positioning system (GPS) equipment in the survey and the distances between entrepreneurs are calculated by GIS software.

$$p(y_{ij}=1|x_{ij}) = p(y_{ij}^{*}>0|x_{ij}) = p(\beta_{ij}+e_{ij}>0|x_{ij})$$
$$= p(e_{ij}>-\beta x_{ij}|x_{ij}) = 1-\Phi(-\beta x_{ij}) = \Phi(\beta x_{ij}),$$

where $\Phi(.)$ denotes the standard normal cumulative distribution function. Similarly, the probability of no similarity in technology between two producers is:

$$p(y_{ij}=0|x_{ij}) = 1-\Phi(\beta x_{ij}).$$

Therefore, the density of y_{ij} given x_{ij} is

$$f(y|x_{ij}) = [\Phi(\beta x_{ij})]^{y}\ [1-\Phi(\beta x_{ij})]^{1-y} \qquad y=0,1$$

Two measures of the manufacturing techniques are used in the analyses: wood-joining technique and the EMC of wooden furniture. The former is measured by the mortise and tenon joints dummy and the ranking of wood-joining techniques; the latter uses the average EMC for three main products and standardized EMC fluctuations for three main products. As *EMC* merely represents the average quality of three main products, an alternative indicator that can capture fluctuation in these products is considered in the paper. Even a seasoned producer may happen to produce a low-quality piece of work in terms of EMC. Because a relatively high value of *EMC* could result from an extremely high EMC in one of the three products, the standardized variation of the three main pieces of work is added to compensate for this drawback. Wood-joining techniques are ranked in order of increasing difficulty of technology; 15 ranks of wood-joining techniques are listed in Appendix 1. Ethnicity variables E_{ij} include two measurements: whether i and j are members of the ethnic majority and whether they belong to the same ethnic group. The latter is more comprehensive, and is calculated based on mother tongue. In addition, variables capturing dyadic relationships based on furniture producer i's and j's schooling years, occupational background, and experience in furniture production training are included. Moreover, the absolute values of differentiated and summed values of the

variables are added. In the interpretation, a negative marginal effect[18] on the absolute value of the differences indicates positive assortative matching; a large difference in the characteristics results in a lower likelihood of performing the same skills in furniture production. A positive marginal effect on the summed value of the variables is interpreted as a positive relationship between the variables and the number of links. The total number of entrepreneurs in the sample is 234, so in total there are 234 × 233/2 = 27,261 unique enterprise pairs in the data. Standard errors are adjusted by observation i as residual e_{ij} is likely to be correlated with e_{ik}.

Table 4 summarizes the variables used in empirical analyses. The mortise and tenon joint dummy (labeled *Mortise*) averages 0.89, indicating that 89% of producers can perform this wood-joining technique. The ranking of wood-joining techniques (labeled *Ranking*) averages 10.9, indicating that furniture producers use four joining techniques (mortise joints, screws, nails, and glue) all together in one piece of furniture work. In terms of the dryness of timber, the *EMC* of three main products ranges from 1.17 to 2 with a mean of 1.79 and a standard deviation of 0.14. The calculation of standardized EMC fluctuation (labeled *EMC fluctuation*) is the standard deviation of three EMCs divided by *EMC.* A low value of *EMC fluctuation* indicates that three products exhibit good and similar quality. The networking strength variable, *Ethnic networks*, ranges between 0 and 17 with a mean of 2.32 and a big standard deviation of 3.38, indicating that the average number of members of the same ethnic group for a furniture producer is 2 people, but that this varies greatly among producers. The educational variable, *Schooling years,* ranges from 0 to 16 with a mean of 9.53. In terms of workshop size, we note the presence of an outlier: one workshop has 54 employees; hires are otherwise about 4 workers. In the empirical analyses, in order to obtain general estimates, we winsorize this observation from the sample. The variables *Majority*, *Ethnic*, *Production training*, *Past occupation*, and *Incumbent* are dummies.

The dyadic data section of Table 4 lists two ethnicity indicators. *Majority* averages 0.51 while *Ethnic* averages 0.19, indicating that nearly half of producers are from the ethnic majority,

18. To facilitate interpretation, instead of coefficients, the average marginal effect will be reported.

and that the remaining half is extremely ethnically diversified. The two manufacturing technique indicators are differences in *Ranking of wood-joining techniques* and differences in *cvEMC*. The former is calculated as the differential wood-joining ranking of two workshops while the latter is calculated, similarly to the concept of EMC fluctuation, as differences in EMC between workshops *i* and *j*, and divided by the EMC of the two workshops. The geographical distance variable shows the farthest distance between two workshops located in the cluster as 9.12 kilometers while the closest two workshops are adjacent, which indicates that social interaction between two producers across the area is possible in the furniture cluster.

Table 4. Descriptive statistics

		N. of Obs. or unique enterprise pairs	Mean	Min.	Max.	Std. Dev.
Mortise		231	0.89	0	1	0.31
Ranking of wood-joining techniques		231	10.9	2	13	2.5
EMC		223	1.79	1.17	2	0.14
EMC fluctuation		181	0.57	0	0.3	0.06
Ethnic networks (within 1 km)		234	2.32	0	17	3.38
Schooling years		234	9.53	0	16	2.71
Workshop size (N. of employees)		234	4.61	1	54	4.05
Differences between I and J	Ranking of wood-joining techniques	26,909	0.58	0	1	0.49
	EMC (and divided by average EMC of I and J, labeled *cvEMC*)	23,653	0.09	0	0.53	0.08
	Majority	27,261	0.51	0	1	0.5
	Ethnic	27,261	0.19	0	1	0.395
	Production training	27,261	0.44	0	1	0.496
	Previous occupation	27,261	0.41	0	1	0.491
	Incumbent	27,261	0.49	0	1	0.5
	Distance (km)	26,335	2.895	0	9.121	1.631
	Sub-cluster	27,261	0.030	0	1	0.172
	Abs. diff. schooling years	27,261	2.630	0	16	2.793
	Sum schooling years	27,261	19.068	0	32	3.820

Source: Author's calculations based on the survey data.

5. Empirical results

The first hypothesis, of the effect of ethnic networking strength on manufacturing techniques, is examined in Tables 5 and 6. The second hypothesis, that knowledge exchange is more active within an ethnic group than across groups, is examined in Tables 7 and 8.

5.1. Ethnic networks and technology level

Table 5 presents the results for the ethnic network effect on adoption of the sophisticated wood-joining technique *Mortise* and the ranking of joining techniques (labeled *Ranking*). The dependent variable in the *Mortise* section is a binary dummy, while the dependent variable in the *Ranking* section is a continuous variable ranging from 1 to 15. The regressions in the *Mortise* section are examined using a probit model, and the others are examined using an ordered probit model.[19]

Specification (1) of the *Mortise* section is a simple version that includes only the ethnicity variable. Specification (2) adds variables capturing the attributes of furniture entrepreneurs: training program dummies,[20] the *Incumbent* dummy, past occupation dummies, and *Schooling years*[21] as well as the scale of the workshop in terms of the number of employees. Specification (3) adds interaction terms for ethnic networks and the type of training programs, which is expected to analyze the relationship between ethnic networks and a furniture producer's responsiveness to training in manufacturing techniques. Overall, the ethnic network variable proves significant. In terms of magnitudes, in specification (1), the average marginal effect of *Ethnic networks* is 0.012 with a p-value of 0.01, indicating that a one unit increase in the strength of the ethnic network increases the probability of the furniture acquiring mortise techniques by 1.2%. In specification (2), observation of *Ethnic networks* increases the predicted probability

19. We recognize that a probit model with cross-sectional data cannot be completely kept free from endogeneity bias; for example, economic shocks to the output market may change producers' decisions on adoption of skillful joints and at the same time affect workshop size or the composition of ethnic groups. The appropriate and widely used approach for eliminating these biases is the combination of a fixed effect panel regression and an Instrumental Variable (IV) approach in which exogenous variables are highly related to the independent variables but unrelated to the error term. However, due to the limitations of the data, we employed a heteroskedastic probit model instead, which assumes endogeneity between error and workshop size and endogeneity between error and ethnic networks. In the *Mortise* section of Table 5, the estimated average marginal effects of ethnic networks increase on average by 0.001 across specifications and all retain significance at 1%. Therefore, we conclude that endogeneity bias is not a major concern in the analyses.

20. Within the class of training programs, we use producers who were not trained as the baseline.

21. Some may argue for the presence of an endogeneity bias caused by self-selection in *Schooling years* and the dependent variable: producers who attempt to produce sophisticated work are more likely to seek higher education. This scenario is unthinkable in the Arusha context, because none of the producers return to school to learn skills for their furniture business, and few of them graduated from furniture vocational schools.

that furniture producers performed the mortise wood-joining technique. The estimated average marginal effect is positive and significantly different from zero. In contrast to what was expected, training programs and education did not promote producers' manufacturing skills. However, we do not advance too strenuously an interpretation of the estimates for training programs as offering evidence of inefficacy in training or education, as we were not able to identify the content of the training programs in terms of whether or not wood-joining techniques were taught. On the other hand, the insignificant coefficient estimates suggest that an endogeneity bias caused by self-selection on education for pursuing better skills is not applicable in the Arusha context. In specification (3), the terms for interaction between the ethnicity variable and types of production training, *Ethnic networks* × *Informal learning* and *Ethnic networks* × *Formal training*, respectively indicating the members of the ethnic majority who obtained production skills through kinship groups and producers with bigger ethnic networks who were trained through formal training programs, do not affect furniture producers' manufacturing skills, compared to the majority of producers who never received production training. The *Ranking* section of Table 5 uses the ranking of joining techniques as the dependent variable and obtains similar results as in the *Mortise* section. Overall, the estimated coefficients on *Ethnic networks* have positive signs with a p-value of 0.05 across regressions. As a result, Table 5 implies that the *Ethnic* variable is the principal factor increasing the possibility of the particular wood-joining approach implemented by furniture producers. Increasing the number of industrial peers from the same ethnic group by one person increases the possibility of furniture producers being skillful by 1.3%.

Table 6 presets the results of Tobit[22] regressions of the *EMC* and OLS regressions of *EMC fluctuation* on the strength of ethnic networks. Overall, the estimate coefficients on *Ethnic networks* are negative across regressions in Table 6, indicating that the strength of ethnic

22. The Tobit model is employed for the possible presence of inferior *EMCs*. We reran analyses with an OLS model, and the results did not show much change.

networks has a positive effect on producers' production techniques in terms of timber drying; however, the magnitude is not statistically significant. In other words, producers from larger ethnic groups do not outperform those from minority ethnic groups in terms of timber-seasoning technology. As a whole, Table 6 does not support the argument that the strength of the ethnic network contributes to advanced manufacturing techniques. In other words, externalities of the ethnic network such as knowledge exchange are not observed in the timber-drying process. One point worth noting is that, in an unreported analysis, when we regress the whole sample including the workshop with 54 workers, the estimate coefficient on workshop size becomes positive and significant. This indicates that workshop size in terms of the number of employees quantitatively contributes to a high EMC value. We note that the workshop with 54 employees has extremely good performance in terms of timber dryness, recording EMC values of 2 for all its furniture work.

Table 5. Wood-joining techniques

	Mortise (Probit Model)			Ranking (Ordered Probit Model)		
	(1)	(2)	(3)	(1)	(2)	(3)
Ethnic networks	0.012**	0.013**	0.014**	0.056***	0.059***	0.058***
(within 1 km)	(1.98)	(2.01)	(2.14)	(2.74)	(2.70)	(2.64)
Workshop size		0.004	0.003		0.021	0.021
		(0.50)	(0.44)		(0.97)	(0.99)
-Informal learning		0.062	0.027		0.086	0.127
		(0.80)	(0.27)		(0.26)	(0.30)
-Formal training		0.048	0.039		0.167	0.163
		(0.64)	(0.39)		(0.51)	(0.38)
Incumbent		-0.032	-0.097		-0.112	-0.048
		(0.81)	(0.65)		(0.65)	(0.08)
-Furniture-related job		0.044	0.041		0.251	0.254
		(0.85)	(0.80)		(0.96)	(0.96)
-Non furniture-related		-0.001	0.003		0.067	0.061
		(0.02)	(0.08)		(0.35)	(0.32)
Schooling years		0.012	0.012		0.015	0.014
		(1.40)	(1.47)		(0.42)	(0.40)
Ethnic networks ×			0.074			-0.115
Informal learning			(0.79)			(0.18)
Ethnic networks ×			0.032			-0.016
Formal training			(0.25)			(0.03)
Adj_R2	0.018	0.0441	0.0482	0.00823	0.013	0.0131
AIC	159.5	169.4	172.7	561.7	573.2	577.1
BIC	166.4	200.4	210.6	627.1	662.7	673.5
N of Obs.	231	231	231	231	231	231

Note: Within the class of training programs, not trained is the baseline. Similarly, the benchmark for past jobs is no work experience.
For the *Mortise* section, instead of coefficients, average marginal effects are reported in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6. Dryness and ethnic networks

	EMC (Tobit Model)			EMC Fluctuation (OLS)		
	(1)	(2)	(3)	(1)	(2)	(3)
Ethnic networks	-0.002	-0.003	-0.003	0.001	0.001	0.001
(within 1 km)	(0.70)	(0.96)	(1.00)	(0.59)	(0.90)	(1.03)
Workshop size		0.006	0.006		-0.003	-0.003
		(1.50)	(1.57)		(1.33)	(1.55)
-Informal learning		-0.069**	-0.044		0.032**	0.01
		(2.36)	(1.25)		(2.20)	(0.47)
-Formal training		-0.023	-0.003		-0.01	-0.023
		(0.83)	(0.08)		(0.75)	(1.24)
Incumbent		-0.024	0.026		0.018**	-0.017
		(1.25)	(0.56)		(2.14)	(0.82)
-Furniture-related job		0.002	0.004		-0.006	-0.009
		(0.09)	(0.17)		(0.60)	(0.89)
-Non furniture-related job		0.006	0.005		0.002	0.003
		(0.32)	(0.26)		(0.27)	(0.32)
Schooling years		0.006	0.006		0.002	0.002
		(1.14)	(1.11)		(0.94)	(0.99)
Ethnic networks ×			-0.06			0.048*
Informal learning			(1.04)			(1.82)
Ethnic networks ×			-0.049			0.028
Formal training			(0.87)			(1.22)
_Cons	1.795***	1.769***	1.746***	0.055***	0.028	0.047*
	(161.65)	(31.32)	(27.25)	(10.52)	(1.29)	(1.77)
Adj_R2	-0.00299	-0.0775	-0.08			
AIC	-236.2	-240.2	-236.8	-517.6	-529.1	-528.1
BIC	-226	-206.1	-195.9	-511.2	-500.4	-492.9
N of Obs.	222	222	222	180	180	180

Note: * significant at 10%; ** significant at 5%; *** significant at 1%.

5.2 Ethnic networks and technical knowledge exchange

Table 7 presents the results of modeling wood-joining techniques to the effect of ethnic networks, using a dyadic dataset. The dependent variable is a dummy that equals one if furniture producer i has same wood-joining skill as producer j. As the dependent variable is a district variable, the probit model is employed for the analyses. A positive coefficient indicates that an increase in the marginal value of the independent variable increases the possibility of i and j having the same wood-joining skill.

Overall, Table 7 shows support for a positive effect of ethnicity on technical knowledge exchange. Two principal ethnicity variables, labeled *Majority* and *Ethnic*, are jointly included in all specifications. *Majority* is a dummy which equals one if both producers i and j are

members of the ethnic majority, and zero otherwise; *Ethnic* is a more comprehensive variable defined based on a producer's ethnicity, which equals one if producer i shares the same mother tongue as producer j. Both specifications (1) and (2) include only the ethnicity variables. While specification (1) uses the full sample, specification (2) is restricted to a subsample of ethnic networks within a 1 km radius of a firm. Specification (3) includes the ethnicity variables that potentially affect a producer's wood-joining skills. Because the joining approaches adopted in a product may change according to the product, the specifications following specification (3) are subsamples that are divided along product lines.[23] The estimates in specification (1) show that *Majority* has a significantly negative sign, indicating that two producers from the ethnic majority are less likely to employ the same wood-joining techniques. In contrast, a significantly positive sign for *Ethnic* indicates that two producers from the same ethnic minority group are more likely to employ the same joining approach. These suggest a higher probability of producers sharing technical knowledge within an ethnic group than across ethnic groups; however, knowledge exchange in the majority appears not to be as active as that in the minority ethnic groups. When observations are restricted to those within a 1 km radius, as shown in specification (2), the coefficients (regardless of sign) become greater and remain significant, indicating that the ethnic networking effect is enhanced over short distances. When other factors are added in specification (3), the coefficients on the two ethnicity variables do not show much change compared with those in specification (1).

The estimates of the ethnic networking effect on timber dryness using dyadic data analysis are shown in Table 8. The dependent variable is *cvEMC*, a high value of which indicates large differences in product quality between two producers. OLS regressions are employed, as *cvEMC* exhibits a normal distribution. A positive coefficient indicates that an increase in the marginal value of the independent variable increases the possibility of i and j having

23. Due to observation constraints for some product items, the results of regressions on some products are omitted.

different timber drying skills. Therefore, significantly negative coefficients are anticipated on the ethnicity variables, *Majority* and *Ethnic*, which is interpreted as indicating that ethnicity decreases the differences in timber drying skills between two producers. However, overall, Table 8 shows little evidence supporting a networking effect on this skill. The signs on *Majority* are as expected but insignificant, while the signs on *Ethnic* are the opposite of our expectations and remain insignificant. These indicate that the timber seasoning schedule does not reflect producers' ethnic interactions. In specification (1), smaller differences in product quality between two producers are associated with their ethnicity. More specifically, it appears that two ethnic Chagga producers produce similar product quality in terms of moisture content. However, the magnitude is not statistically significant. In specification (2), the coefficient estimates of *Distance* prove negative. Using a subsample, specification (3) reports the results for individual furniture products. The results do not show much change compared to those in specification (2). On the whole, the constant terms across the specifications remain significant and positive, and the goodness of fit indicators AIC and BIC retain large values across regressions, indicating that substantial unexplained factors remain in the model specifications. The results in Table 8 are consistent with those reported in Table 6, indicating that ethnic networks do not promote producers' manufacturing skills in terms of timber treatments. There are four possible reasons for the inconsistent results. The first, and the most important, is that, as explained in the last paragraph of section 5.1, the moisture content of timber is extremely sensitive to the environment. Given the dearth of temperature-control facilities, moisture content is not as easily self-controlled as wood-joining techniques; this attribute makes it difficult for producers to learn from others. Second, to save on material costs, not a few customers bring their own timber and self-designed patterns to furniture workshops. In these cases, furniture producers do not seem to proceed with further desiccation treatment on the timber. Third, and related to the second point, it could be the case that the effect of ethnic networks is reflected in other aspects, such as timber

trading, rather than on timber drying. Lastly, the technology learning path may differ between timber seasoning and timber assembly.

To sum up, Table 7 shows that producers from the same ethnic group are more likely to exchange knowledge with each other, whereas producers from the ethnic majority are reluctant to do so. In contrast, Table 8 shows that members of the ethnic majority moderately share timber drying techniques with members of their own ethnic group while members of ethnic minority groups do not do so; however, the overall results are not statistically significant. Considering the results from Tables 5 and 6, as well as from Tables 7 and 8, we conclude that minority ethnic groups share technical knowledge within their own groups, but that this knowledge exchange is only effective to the extent that the technology involved is not very high.

Table 7. Wood-joining techniques and ethnic networks

	(1)	(2)	(3)					
	(within a 1 km raidus)			Sofa	Bed	Dining Set	Cabinet	Couch
Majority	-0.17***	-0.223***	-0.168***	-0.161**	-0.025	-0.05	0.06	0.132
	(2.63)	(2.84)	(2.61)	(2.37)	(0.31)	(0.55)	(0.59)	(1.00)
Ethnic	0.312**	0.413***	0.309**	0.334**	0.027	-0.002	-0.144	-0.268
	(2.17)	(2.89)	(2.14)	(2.03)	(0.17)	(0.01)	(0.81)	(1.30)
Distance			0.009	0.044	-0.018	0.036	-0.034	0.035
			(0.31)	(1.49)	(0.57)	(0.96)	(1.01)	(1.01)
Production training			-0.009	0.035	0.159***	0.035	-0.041	0.118
			(0.21)	(0.78)	(2.80)	(0.90)	(0.68)	(1.29)
Incumbent			0.006	-0.013	0.015	0.025	0.028	0.11
			(0.22)	(0.89)	(0.55)	(0.83)	(0.53)	(1.22)
Previous occupation			-0.076**	0.004	-0.025	0.348***	-0.091***	-0.085***
			(2.18)	(0.08)	(0.62)	(3.05)	(3.25)	(2.75)
Diff-workshop size			-0.006	-0.006	0.028	-0.011	0	-0.001
			(0.84)	(0.85)	(1.31)	(1.11)	(0.02)	(0.03)
Sum-workshop size			-0.011	0.006	-0.046**	0.008	-0.002	-0.078***
			(1.40)	(0.80)	(2.14)	(0.79)	(0.19)	(2.69)
Diff-schooling years			-0.032**	-0.018	0.006	-0.02	-0.017	0.008
			(2.02)	(1.06)	(0.36)	(1.12)	(0.90)	(0.37)
Sum-schooling years			-0.002	0.006	0.005	0.002	0.001	-0.031
			(0.15)	(0.35)	(0.31)	(0.12)	(0.08)	(1.39)
_Cons	0.220***	0.370***	0.347	-0.256	-0.588*	-1.313***	-0.681*	-0.376
	(2.75)	(4.27)	(1.10)	(0.76)	(1.89)	(3.48)	(1.78)	(0.88)
Adj_R2	0.00568	0.01	0.0142	0.0129	0.0188	0.0247	0.00557	0.039
AIC	36468.4	3411.8	34708	24037.8	9354	6996.2	6434.2	3642.3
BIC	36493	3429.4	34797.8	24123.3	9432.2	7072.6	6508.2	3713.8
N of Obs.	26909	2615	25991	17567	9027	7641	6214	4912

(Probit model using dyadic data analysis)
Note: Average marginal effect is reported instead of coefficient. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 8. The cvEMC and ethnic networks (OLS using dyadic data)

	(1)	(2)	(3)					
	(within a 1 km raidus)			Bed	Couch	Cupboard	Cabinet	Table
Majority	-0.003	-0.006	-0.003	-0.008	0.006	-0.001	-0.019***	-0.005
	(1.14)	(1.13)	(1.30)	(1.40)	(1.01)	(0.17)	(3.85)	(0.45)
Ethnic	0.006	0.001	0.007*	0.01	-0.006	0.009	0.031***	0.026
	(1.57)	(0.09)	(1.70)	(1.09)	(0.53)	(1.02)	(5.59)	(1.40)
Distance			-0.002**	-0.004***	-0.003	0	-0.003*	-0.009***
			(2.16)	(2.75)	(1.52)	(0.13)	(1.77)	(3.22)
Production training			-0.001	0.001	0.002	0.006	0.005*	0.017
			(0.66)	(0.50)	(0.61)	(1.56)	(1.72)	(1.03)
Incumbent			0	0.001	0.004	-0.001	0.006*	0.005
			(0.41)	(0.37)	(0.96)	(0.21)	(1.87)	(0.72)
Previous occupation			0.005***	0.004	0.003	0.023**	0.002	0.013
			(3.14)	(1.30)	(0.86)	(2.48)	(1.01)	(1.03)
Diff-workshop size			0	0	-0.007***	0	0	-0.011***
			(1.35)	(0.77)	(3.48)	(0.97)	(0.36)	(5.29)
Sum-workshop size			0	0	-0.005***	0.001***	0	-0.013***
			(0.97)	(0.63)	(2.93)	(3.40)	(0.38)	(5.19)
Diff-schooling years			0.001	0	0.004***	0.003	-0.001	-0.002
			(0.57)	(0.22)	(4.03)	(0.71)	(1.54)	(1.02)
Sum-schooling years			-0.001	0.002	0.003***	-0.007**	-0.003***	0
			(1.32)	(1.35)	(2.93)	(2.53)	(5.60)	(0.25)
_Cons	0.089***	0.093***	0.117***	0.097***	0.083***	0.191***	0.143***	0.214***
	(34.20)	(19.62)	(5.63)	(4.24)	(3.95)	(3.71)	(10.53)	(5.89)
AIC	-53417.9	-4830	-51506.3	-14086.6	-2710.2	-3550.4	-3607.1	-630.6
BIC	-53393.7	-4812.7	-51417.9	-14008.2	-2652.3	-3492.5	-3549.2	-582.3
N of Obs.	23653	2331	22791	9180	1431	1431	1431	595

Note: * significant at 10%; ** significant at 5%; *** significant at 1%.

6. Conclusions and policy implications

Using individual-level data on 234 furniture workshops located in the furniture cluster of the city of Arusha, Tanzania, this study explored the effect of ethnicity on technical knowledge exchange among small- and micro-scale entrepreneurs. The results obtained from empirical analyses show that furniture producers' ethnic networks predict the achievement of mastery of a production skill; producers who have more people of the same ethnicity operating furniture workshops within a 1 km radius exhibit high levels of production process manufacturing techniques. Moreover, two entrepreneurs sharing the same ethnic background are more likely to perform similar manufacturing techniques, but this takes place only if they are from the same minority ethnic group. We infer from these findings that knowledge exchange is more active within each ethnic group than across ethnic groups, and in minority ethnic groups rather than in the ethnic majority. Once an ethnic group grows rapidly and becomes an

overwhelming majority group in the industry, producers become reluctant to share business information with each other. Once the members of the ethnic majority turn to such a negative attitude with regard to technical knowledge interactions, its members may lose their advantage in information accessibility and eventually fall into a minority position, as hostile attitudes could discourage newcomers from the same group from entering the cluster. We observe that this scenario is actually taking place in the Arusha cluster; the ethnic composition of its producer population is becoming more diverse. On the other hand, our results show that ethnic networks have no influence on timber-seasoning skills, in which capital-intensive facilities are necessary; ethnic networks have difficulty in overcoming capital constraints. This result is similar to Munshi's (2004) finding that technical learning outcomes strongly depend on the individual characteristics of the subjects to be learned. More specifically, knowledge learning (exchange) breaks down if the nature of the technology involved is unobserved, or imperfectly observed.

Based on the empirical findings, suggestions for policymakers are that, as learning resources are still limited in African countries, specialized training with respect to production, marketing, and business management should be introduced for enterprises located in industrial clusters that are still at the initial stage of development. Of course, it would be ideal to train all entrepreneurs who are in need. However, this may not be feasible due to budget constraints. In such a case, as the likelihood of technical knowledge exchange increases according to the strength of ethnic networks, training program organizers should invite entrepreneurs from various ethnic groups, in particular from ethnic minority groups, rather than randomly selecting participants. However, as the issue of ethnicity is sensitive, and potentially taboo in most African countries, an improper policy may raise disturbing questions about racial and ethnic conflict, and thus training program organizers should keep such sampling methods undisclosed. In addition, capital constraints remain a matter of concern in African countries. Because some manufacturing techniques such as the timber seasoning schedule are difficult to practice without

advanced facilities, loans for purchasing related machinery should be provided as an indispensable component of industrial development policy.

Lastly, the author is aware of the limitations of this study. First, because of the limitations of the data, this study only observes knowledge exchange among the cluster-based furniture producers in Arusha; it cannot rule out the possibility that these producers acquire their knowledge outside the clusters. Further studies are required to track knowledge diffusion within the same ethnic group located both inside and outside an industrial cluster. Due to the lack of available data, this paper was also unable explore the possibility that ethnic networks may have been instrumental in raising capital, recruiting labor, and dealing with suppliers and customers.

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Appendix 1 lists the rating of wood-joining techniques. Basically, a technique that does not involve any materials such as screws, nails, and glue is called a mortise and tenon joint, and is considered to be a sophisticated approach superior to screwing or nailing joints. After metal-using joints, gluing is the easiest and cheapest of all to make. The table comprises the 15 permutations and combinations of wood-joining techniques that Arusha furniture producers perform. The ranking rules are: joints including mortise joints are ranked higher than those using screws; joints including nails are always ranked below screwed joints; joints with glue are inferior to those using nails. Accordingly, a higher ranking indicates a superior manufacturing technique.

Appendix 1
Ranking of wood-joining techniques

Ranking	Wood	Screw	Nail	Glue
15	○			
14	○	○		
13	○	○	○	
12	○		○	
11	○	○		○
10	○	○	○	○
9	○		○	○
8	○			○
7		○		
6		○	○	
5		○	○	○
4		○		○
3			○	
2			○	○
1				○

Abstract (in Japanese)

要約

本研究はタンザニア、アルーシャ市の家具集積地に立地する家具製作所、234 軒の企業データを用い、産業集積地で起こる家具生産者間の技術的な知識交換のメカニズムを検証する。ここで知識交換は、同一の産業クラスターに属する家具生産者間で、生産工程において同様の生産技術を用いることと定義される。実証分析の結果、民族のネットワークの強さ（同民族の人数）が生産技術の獲得に対し、有意にプラスの効果を持ち、特に生産設備に依存せず、主に家具生産者自身の技術頼る木材の接合技術などに対して影響があることが明らかになった。さらに家具製作者の二者間データを用い、たとえ両生産者が同一民族であったとしても、2 人が同一多数民族であるケースより、2 人が同一少数民族である場合のほうがより同一の生産技術を用いる確率が高いことを明らかにした。これらの実証結果は、民族ネットワークが産業クラスター内の知識交換を促進することを明らかにしたが、民族ネットワークの持つ正の外部性には限界があり、知識交換は少数民族グループ内でしか起こらず、かつ精密機器や設備の必要のない技術に限られていることを示唆する。

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