Social Networks 73 (2023) 89–103

Contents lists available at ScienceDirect

Social Networks

journal homepage: www.elsevier.com/locate/socnet

Does “network closure” beef up firms’ performance?

Alessio Muscillo [a], Paolo Pin [a,b,*], Tiziano Razzolini [a,d], Francesco Serti [c,e]

[a] Department of Economics and Statistics, University of Siena, Italy
[b] BIDSA, Bocconi University, Italy
[c] IMT School for Advanced Studies Lucca, Italy
[d] IZA Institute of Labor Economics, Germany
[e] University of Alicante, Spain

ARTICLE INFO

JEL classification:
D22
D85
F10
F14
L14
O13

Keywords:
Import premium
Network closure
Sequential supply chain

ABSTRACT

In this paper we study whether “network closure” in the supply chain can explain the heterogeneity observed in firms’ performance. Using unique panel data on trade flows among beef farms in the Italian region of Piedmont, we analyze a sequential supply chain characterized by the co-existence of two production goods: domestic cattle, of lower quality but less risky, and imported cattle, of higher quality but exposed to higher risks. Our findings indicate that network closure, a characteristic commonly linked to the enhancement of trustworthy relations and mutual cooperation, is associated with an increase in the performance of farms adopting the riskier production system. On the other hand, network closure does not affect the performance of farms using the more traditional and mature technology. Thus, trust may promote the use of inputs of superior quality.

1. Introduction

Economic sociology has contributed to describe how the economic activity is embedded in a social environment. This has proved to be particularly useful in economics and organization theory literature to describe and explain firms’ strategic behaviors and mechanisms at play in inter-organizational networks. In presence of uncertainty (risky investments, incomplete contracts, partners’ opportunistic behaviors, etc), establishing trustworthy relations with business partners is fundamental for firms’ performance (Granovetter, 1985; Uzzi, 1996, 1997; Gulati, 1998). Then, understanding the interplay between firms’ behavior and firms’ connections becomes of crucial importance when looking for the answer to the “performance question, which is why some actors have better outcomes than others” (Borgatti and Li, 2009).

Transactions and interactions between economic agents can be fostered and maintained thanks to both relational embeddedness and structural embeddedness (Granovetter, 1992). The first one refers to the quality and strength of interpersonal ties and thus focuses on the cohesion of dyadic relations. Structural embeddedness “refers to the fact that economic action and outcomes, like all social action and outcomes, are affected [ ] by the structure of the overall network of relations” (Granovetter, 1992) and thus helps avoiding the simplification and reductionism of “dyadic atomization”. The importance and role of third parties and the “the idea that social triads are fundamentally different in character from dyads” (Krackhardt, 1999) is also studied and formalized by the literature on Simmelian ties. Several studies on alliances and joint ventures have focused on the role of common business partners on their stability (Gulati, 1995; Polidoro Jr. et al., 2011; Schilling and Phelps, 2007). Others have specifically focused on the role of a third party which transforms a dyadic relation into a “closed” triad – aspect called “social network closure” – because it enables mechanisms of referral, social monitoring and trust enforcement (Coleman, 1988; Gulati, 1998; Nooteboom, 1999). However, because of the multiplicity of business lines, variety of purposes and complexity of the products analyzed, this literature is often unable to identify these mechanisms and disentangle their direct impact on firms’ performance.

In this paper, we exploit longitudinal production network data on firm-to-firm transactions to contribute to the extant literature on the “advantages of structural embeddedness (partners that collaborating firms have in common)” (Polidoro Jr. et al., 2011). We first build a stylized game theoretical model where firms live in an environment where trade relationships are characterized by asymmetric information, unobserved quality and relation-specific costs and show that specific network structures are able to promote trustworthy relations and behaviors which help enhancing firms’ performance. Secondly,

* Corresponding author at: Department of Economics and Statistics, University of Siena, Italy.
E-mail address: paolo.pin@unisi.it (P. Pin).

https://doi.org/10.1016/j.socnet.2023.01.004

Available online 24 January 2023

we show that the hypotheses made are consistent with the results of our empirical analysis and that, in particular, the benefits from using high-risk high-quality imported inputs are enjoyed the most by firms embedded in specifically structured ego-networks characterized by closed triads (Coleman, 1988; Granovetter, 1992; Krackhardt, 1999). By exploiting the information on all firms' transactions, we approximate the extent to which an economic agent is embedded in such network configurations by measuring the proportion of closed trade relationships over all the potential triads. We operationalize this notion by using an edge property called "support" (see Fig. 1 and Jackson et al. 2012). With the help of a game-theoretical model, we show that network closure may trigger reputation concerns and pro-social behavior useful for sustaining successful business relations. Thus, in the empirical analysis, we exploit fine-grained information to estimate productivity at the farm level and see how it correlates with network measures built at the farm level and at the owner level (see Figs. 3 and 4). The intuition behind why network closure/support helps improve the use of the imported technology comes from the assumption that using the imported technology requires productive interaction with another importer, while there is no analogous requirement for the domestic technology. That productive interaction requires trust, and since there is no formal contract enforcement, trust between two farmers is stronger when they have a common partner together (and this is measured by support).

While most of the previous literature has analyzed R&D-intensive firms and multinational enterprises that produce very heterogeneous goods and that are organized in complex supply chains (Gulati, 1998; Gulati and Gargiulo, 1999; Uzzi and Spiro, 2005; Schilling and Phelps, 2007; Batjargal, 2007; Baum et al., 2010; Polidoro Jr. et al., 2011; Bellamy et al., 2014), for our analysis we use the special case of beef farming, which constitutes an excellent setting to study the relation between network closure and firm performance. Even if commonly considered a mature sector, beef farming has undergone major improvements in genomics and breeding techniques that have fostered the development of breeds that largely outperform the traditional ones (Field, 2017).[1] In Italy, 46% of bovines raised for meat production are imported from countries, such as France, that have historically exhibited a comparative advantage in selecting and reproducing highly-performing breeds (Rama, 2008, 2009, 2010, 2011, 2012).[2] By contrast, as a result of a selection process over hundreds of years, farming of less productive domestic breeds better fit local conditions such as climate, food and local diseases and it is more integrated with local agricultural production. Farmers' convenience to substitute local bovines with imported ones depends on the trade-off between the better performance of the foreign breeds (e.g. the ability to grow faster) and the higher uncertainty associated with their adoption.[3] On the one hand, the cost of imported animals is higher and subject to larger price fluctuations (Rama, 2008, 2009, 2010, 2011, 2012, 2014; Sarzeaud et al., 2008) and these external factors lead to a variability over time in the proportion of foreign bovines reared in a farm. On the other hand, although the two production systems can co-exist, foreign cattle is a biological asset whose superior performance requires specific know-how and the provision of adequate housing conditions.[4] Therefore, trade exchanges involving foreign cattle are characterized by higher relation-specific costs and problems of unobserved quality and asymmetric information.[5] In such a situation, where writing complete contracts is relatively more complex and costly, we show that network closure turns out to be an important element to stimulate more cooperative and efficient behaviors.

Another crucial advantage of this sectoral case study is the clean sequentiality of the production phases at plant level: animals change location/stable as they grow. This sectoral feature of the production process helps considerably in identifying the role of the network and facilitates the measurement of plant-level performance.[6] In other industries, where complex goods are produced by employing multiple business lines, productivity gains may derive from complex interactions and technological complementarities among all the actors and inputs in the chain. Instead, in our case, the productivity gains commonly observed in firms using imported intermediate inputs (Kasahara and Rodrigue, 2008) neatly follow from the adoption of better inputs.[7]

We conclude this introduction by summarizing the paper. In Section 2 we build a theoretical model that captures all the above-mentioned features and where new business opportunities arise and are caught on the basis of previous trade relations. Section 3 describes the data in detail. In Section 4, we then study whether the model's predictions are consistent with what we observe by using plant-level longitudinal data about the population of farms (about 10,000) raising cattle in the Italian region of Piedmont (Fig. 2). From the data, we are able to build the supplier–buyer network of firm-to-firm exchanges and the social network of owners and follow their dynamics over time. Trust between a firm and its partners is built and maintained if the trade network is such that firm-partner relationships are "supported" (see Fig. 1). The performance gains associated to the use of the high-quality imported goods are increasing in the share of the firm-to-firm relationships that are "supported". In contrast, the "advantages of structural embeddedness" (Polidoro Jr. et al., 2011) do not generate gains for firms using only the relatively less complex low-quality (low-risk) domestic inputs. In Section 4.3 we consider alternative potential explanations and we show that our main results are robust to controlling for other local/micro and global/macro features of the production network and for the existence of economies of agglomeration at the geographical and industrial level. Lastly, Section 5 concludes the paper.

2. A model of production of an imported good

The sociological literature (Granovetter, 1985; Putnam, 2000; Coleman, 2000) has long argued that particular social network structures play a key role in building and maintaining trust among agents and

[1] Breeds characterized by a higher ability of transforming feed intake into pounds of animal weight, a.k.a. *feed conversion ratio*. This advantage guarantees faster growth rates and better achievements in terms of mass weight at slaughter age (Rama, 2008, 2009, 2010, 2011, 2012; Field, 2017). Selected breeds also display a better distribution of intramuscular fat which improves the tenderness of the meat (Field, 2017).

[2] A crucial aspect is that of subsidies given to farmers, corresponding to specific production phases. It is the case of France with respect to the first phases of the animals' lives. In general, "member states [of the European Union] can opt for keeping up to 100% of the "suckler cow premium" and up to 40% of the "slaughter premium" for adult bovine animals' coupled". In particular, "France decided to leave the whole suckler cow premium and 40% of the slaughter premium coupled". (Sarzeaud et al., 2008)

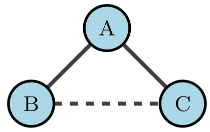
[3] The overall economic activity of farms revolves around the investment in the biological asset. For the so-called open-cycle farms that buy already-grown animals to fatten them (mainly importers), the purchase of the animal accounts for between 1/3 and 1/2 of the total per-kilogram production costs (see Rama, 2008, 2009, 2010, 2011, 2012, 2014 and the reportbytheItalianInstituteofServicesforFoodandAgriculturalMarkets(ISMEA), specifically Table 3.7 and Table 4.6.)

[4] The direct (re)production of foreign cattle is not typically attempted by farms, as this would require drastic investments in capital and technology.

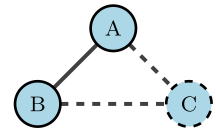
[5] For example, animals often suffer from diseases that are latent for long time but that can heavily affect their growth and, ultimately, their weight at slaughter age (Field, 2017).

[6] A firm's performance is directly measured by the number of bovines produced and depends on the speed at which animals grow. In turn, an animal's growth rate depends on its breed. Moreover, the other inputs used for production are mostly fixed, so performance crucially depends on raising technique and animal's quality.

[7] This aspect is also called "quality channel", as opposed to the "variety channel", which attributes productivity gains to other complementarities (Halpern et al., 2015).



(a) Clustering: what is the probability that two neighbors of A are also neighbors with each other?



(b) Support: given a link between A and B, what is the probability that there exists a third node C that is also linked to both A and B? Notice that it is an edge property.

Fig. 1. Network closure.

promoting behaviors that are compatible and in line with trustworthy relations. Trust, in turn, fosters cooperative and efficient behaviors that end up positively affecting economic outcomes. This line of reasoning has been applied effectively in social contexts where interactions among agents are assumed to be repeated over time and occurring without formal contracts (Board, 2011; Dall'Asta et al., 2012). Specifically, it has been shown that the main structural characteristic related to trust is network "closure" (Ali and Miller, 2016; Karlan et al., 2009).

Drawing on this literature, we build a model based on a variation of the one in Jackson et al. (2012), where agents who decide to produce using foreign inputs do so only if the supply chain in which they are embedded is structured in "closely knit"/clustered local connections, able to ensure the right incentives to sustain sunk investments in the biological asset and relation-specific costs necessary for the production of the high quality (imported) good.

The variation in our model, with respect to Jackson et al. (2012), is that we add an initial stage where players decide if they want to become importer or not. Specifically, firms are producers of a domestic good (i.e. cattle) and are part of a network defined by their trade relationships (i.e. supplier–client or input–output linkages). Such a network is considered pre-existing and exogenously given. The interpretation of this assumption is that the network is made of trading partnerships that are established at the time when the other decisions that we model are taken. In addition, a firm can choose to use imported inputs (i.e. foreign breeds), with the assumption that these are of higher quality, more profitable but also more complex to deal with. Such firms are named importers.[8] To become importers, firms have to pay a sunk investment in the biological asset which, in the case of foreign breeds, accounts for up to around half of the total production costs.[9] Moreover, there are also breed-specific investments needed to treat the foreign good, such as adequate housing, knowledge of breed-specific raising techniques and so forth.[10] Firms who decide not to become importers remain active only in the production network of the domestic good, and being a non-importer is formalized as a no-risk outside option which always yields a net profit normalized to 0. This is considered to be a less risky choice which requires less investments both in terms of physical and biological assets and in terms of learning/acquiring breed-specific know-how.

We now focus our attention to the description of the importers. While the foreign input is potentially more productive and profitable, it is also riskier and more complex to adopt and produce. Once a firm has paid the sunk cost for importing, then she has access to a broader set of business opportunities given by the possibility of producing the high quality good. However, the complexity of the imported good, the specialization in (breed- and) age-specific housing and investments and, ultimately, the sequentiality of cattle raising production, make collaboration among different importers in the production chain necessary to enjoy the higher productivity yielded by foreign breeds.

In particular, when an importer i is presented with a business opportunity, she needs the cooperation of another importer j to catch it, for example because j is downstream in the production chain with respect to i and i needs to ensure j's demand. This is formalized as a relation-specific investment paid by j, corresponding to customization costs of j to i's inputs.[11] In the end, i is able to enjoy the benefit yielded by the production of the high-quality good only if j has borne this relation-specific cost. Notice that j is also an importer so, symmetrically, there may well occur a situation in a successive time period where j may ask i to reciprocate the investment for an opportunity she has been presented.

Crucially, however, problems due to incomplete contracts are pervasive, because no binding agreement can be used to force firm i to reciprocate. Also, monitoring the partner may be a concern, since the quality of the traded foreign good and the effort exerted in raising the animals are both unobservable. In a context like this, trust and reputation are important to sustain collaboration and j's response to i's refusal to reciprocate is formalized as the cut of their trade relationship.

The main features of this model can be summarized as follows (we will be more precise on the timing of the game below, when the model is introduced formally):

- Firms have a sunk cost $s > 0$ to pay to become importers.[12] Moreover, each firm has a specific discount factor δ_i over time. Time is assumed to be discrete in $\{0, 1, 2, \dots\}$.
- Importing is a risky but profitable activity: with some probability, an importing firm faces a business opportunity but is able to catch it only if she can share it with an importer partner who, in turn, is asked for a (relation-specific) investment. More precisely: if i and j are linked (and they are both importers), then there is a probability p_{ij} that i is presented an opportunity that can be shared with j. Time periods are assumed small enough so that at most one business opportunity can arise in each time period across all firms, i.e. $p_{ij} \leq \frac{1}{n(n-1)}$ for all $i, j \in N$.
- In response to this event/opportunity, j can choose either to reject it or to accept it: if rejection is chosen, no benefit is enjoyed nor cost incurred, but the relationship is severed.[13] Instead, if j accepts the offer, then j bears a cost $c_{ji} > 0$ for the investment and i enjoys a benefit of $v_{ij} > c_{ji}$, which abstractly represents the intensity and profitability of the trade relationship between i and j.[14] Moreover, in case of j's acceptance, the relationship ij is

[8] We indicate by importers not only those producers who directly import the foreign cattle, but also those who participate in the production chain of a cattle which was born abroad.

[9] See the Italian Institute of Services for Food and Agricultural Markets (ISMEA) reports (for example, the 2006 ISMEA's report [link]).

[10] Fixed or sunk cost of importing are a common feature in the literature (Kasahara and Rodrigue, 2008; Kasahara and Lapham, 2013; Halpern et al., 2015).

[11] Relation-specific costs are also present in Carvalho and Voigtländer (2014) and Bernard et al. (2015).

[12] This cost may be randomly distributed across firms in an interval or in a discrete set, e.g. in a finite set of low and high costs $\{s_L, s_H\}$. In general, it can be firm specific and the analysis remains the same.

[13] And it can never be resuscitated (at least in the short-run).

[14] Heterogeneity in trade relationships is allowed and also considered in the empirical analysis of Section 4. Notice, however, that for tractability reasons in the model the intensity v_{ij} of the relationship ij is constant over time.

maintained and future opportunities for the two firms can arise again.

- If a firm decides not to become an importer (i.e. it does not pay the sunk cost s), then it does not have access to any business opportunities involving foreign goods, so it keeps its relations with non-importer partners in place and enjoys a payoff of 0 in perpetuity.[15]

In this framework, on the one hand it is ex-ante Pareto optimal for importers to invest in each others' business opportunities over time but, on the other hand, in absence of binding agreements firms could free-ride by not reciprocating the investment. The punishment for free riding, i.e. the deletion of the trade relationship, can have negative cascade effects to other relationships and is then able to ensure the right incentives and high levels of trust among the firms that, in turn, sustain the optimal equilibrium achieved thanks to collaboration.

From a network perspective, maintaining links with other importers is costly but guarantees access to a possibly superior payoff obtained with the more productive input. Importing firms who achieve a sufficiently high degree of collaboration with other importers manage to compensate the sunk cost paid and can enjoy higher payoffs, whereas those who cannot will find it more convenient to keep their production restricted to the low-performing domestic good.

2.1. The game

A finite set of firms $N = \{1, \dots, n\}$ is placed on a network represented by a graph g, where $N_i(g)$ is the set of neighbors of firm i in the network and $d_i(g) = |N_i(g)|$ is i's degree in g. A link between two firms is present if they have a trade relationship. A link is said to be *supported* if there exists a third firm who is a common neighbor.[16]

At the beginning, the parameters s, δ_i, p_{ij}, c_{ij} and v_{ij} for all firms i, j are given and the network g is in place. In all generality, these parameters are specific to relationships and, in addition, may also depend on the network structure g, so they can be of the form $p_{ij}(g)$, $c_{ij}(g)$ and $v_{ij}(g)$. A society is described by $\left(N, s, \{\delta_i\}_{i\in N}, \{p_{ij}\}_{i,j\in N}, \{c_{ij}\}_{i,j\in N}, \{v_{ij}\}_{i,j\in N}, g\right)$.

A 2-stage game with complete information then begins, where the first stage is one-shot while the second stage evolves over discrete times, $t \in \{0, 1, \dots\}$.[17]

Stage 1 (One-shot import decision)

Each firm decides whether to become an importer or not:

- if firm i decides to be an importer, then it pays the sunk cost s and has access to the following stage of the game;
- otherwise, no cost is paid nor benefit enjoyed. So, a non-importer remains part of the trade network g, thus interacting with other non-importers. She will not get any additional benefit thus obtaining a net payoff normalized to 0.

Let us denote by $N^I \subseteq N$ the subset of firms who are importers and, correspondingly, by $g^I = g|_{N^I}$ the subnetwork of g induced by the importers. We call $d_i(g^I)$ the degree of node i in the subnetwork g^I.[18]

Stage 2 (Import with collaborations)

Importing firms choose the other importers they want to be linked to or, rather, the collaborations with other importers they want to maintain, while knowing that collaboration among importers is costly but valuable.

- At time $t = 0$, the network g is in place and, hence, the subnetwork of importers $g_0 = g^I$ is taken as starting point;
- time is discrete, and period t begins with (sub)network $g_{t-1} \subseteq g_0$ in place. Nodes of g_{t-1} announce the links they want to retain and the resulting network $g'_t \subseteq g_0$ is formed, where links are present only if mutually announced. Formally, for $i \in g_{t-1}$, let $L(i) \subseteq N_i(g_{t-1})$ be the set of i's neighbors that i announces. Then, $g'_t \subseteq g_{t-1}$ is defined by taking only the links $ij \in g_{t-1}$ such that $i \in L(j)$ and $j \in L(i)$;
- according to the distribution $\{p_{ij}\}_{i,j}$, the (directed) link ij is selected with probability p_{ij}. If $ij \notin g'_t$, then nothing happens and time t ends with network g'_t in place. Otherwise, i is presented an opportunity and asks j to invest in it. Then:
  - if j rejects, no cost and no benefit are incurred and the resulting network at time t is $g'_t - ij$;[19]
  - if j accepts, i enjoys the benefit v_{ij} while j pays the investment cost c_{ji}, and the resulting network is g'_t.

The initial network of importers g_0 is a subnetwork of the given exogenous trade network g, and the same holds for the equilibrium subnetwork of importers resulting from the game. Also, notice that we are assuming that trade relationships cannot resuscitate once cut. This is a reasonable assumption if one considers that trust among partners is usually established through interactions occurring over several years. Moreover, our data span around 6 years and since each stage of cattle production typically lasts few months, this limits the number of possible interactions that farmers could have had in this time period. Crucially, this also limits the possibility of re-establishing a closed relationship (that is, the possibility of forgiving a free rider) in what is a relatively short-time horizon.

Lastly, notice that consistently with the market considered here, in this model the production of the local good is assumed to be less complex and, hence, to imply less restrictions on the trade partners. This is formalized by the generality of the exogenously given network g.

2.2. Solution of the game and predictions

The 2-stage game can be solved by backward induction, as done in Jackson et al. (2012): the second stage has a solution, based on the concept of *renegotiation-proof* equilibrium, such that the equilibrium subnetworks of importers are those where all their links are supported, i.e. where all links between two importers are supported by another importer. Then, a firm decides to be an importer in the first stage only if it anticipates that the benefits obtained by collaborating with other importers in the equilibrium network will exceed its sunk cost.

Since, by construction, the non-importers get the outside-option payoff of 0, in what follows we focus on the network structures among importers that result in equilibrium and in their payoffs. We show that the import premium obtained by the importers is increasing in the number of supported relationships (with other importers) that they are able to sustain in equilibrium and, hence, in their involvement in importing. From the network-theory perspective, the interesting cases

[15] It is assumed that trade relationships among non-importing firms yield a net payoff normalized to 0.

[16] That is, the link ij is supported in g if there exists $k \neq i, j$ such that $k \in N_i(g) \cap N_j(g)$.

[17] We assume that a firm knows the (cap)abilities of her trading partners and, particularly, knows whether they can raise imported cattle, both in terms of physical assets and in terms of know-how (i.e. a firm knows which of her neighbors has paid the sunk cost to become an importer).

[18] For a subset $S \subseteq N$, we denote by $g|_S$ the subgraph of g induced by S, that is, the graph whose vertices are in S and whose links ij are present if and only if both i and j belong to S.

[19] If $ij \in g$ is a link of g, we indicate by $g - ij$ the network g without that link.

arise when a single link between two importers is not sustainable in isolation, that is, when

$$c_{ji} > \delta_i \frac{p_{ij}v_{ij} - p_{ji}c_{ji}}{1-\delta_i}, \quad (1)$$

for all importers $i, j \in N^I$.

Proposition 1. *Let $(N, s, \{\delta_i\}_{i\in N}, \{p_{ij}\}_{i,j\in N}, \{c_{ij}\}_{i,j\in N}, \{v_{ij}\}_{i,j\in N}, g)$ be a society such that Eq. (1) is satisfied. Then, in equilibrium, the subset of importers $N^I \subseteq N$ and the induced subnetwork $g^I \subseteq g$ are such that:*

- *non-importing firms in $N \setminus N^I$ get a payoff of 0, by construction;*
- *if $i \in N^I$ is an importer then she gets an equilibrium payoff of $u_i(g^I) \geq s > 0$, given by*

$$u_i\left(g^I\right) = \frac{\sum_{j\in N_i(g^I)}\left(p_{ij}v_{ij} - p_{ji}c_{ji}\right)}{1-\delta_i}. \quad (2)$$

- *g^I is such that all its links are supported in g^I.*

Proposition 1 follows from Theorem 3 in Jackson et al. (2012). It is worth remembering that a link between two agents is supported when there is a third agent, in contact with both, who can guarantee one's good behavior with the other. This mechanism is used to enforce pro-social behaviors and sustain high-achieving collaborative outcomes.

Next result is a corollary of that, and comes from the fact that the payoff in equilibrium (2) is linear with the number of importer neighbors $d_i(g^I)$. Recall that $d_i(g)$ is the "exogenous" degree of node i in network g and that $d_i(g^I)$ is the "endogenous" degree of node i in the equilibrium subnetwork $g^I \subseteq g$. For a non-isolated node $i \in N$, we define the *relative degree* as the fraction of i's neighbors that are importers, $\theta_i(g^I) := d_i(g^I)/d_i(g)$, with the convention that $d_i(g^I) = 0$ if $i \notin N^I$.

Proposition 2 (*Productivity and "Relative" Degree*).
Given a network g, if $p_{ij}v_{ij} \geq p_{ji}c_{ji}$, for all $i, j \in N^I$, then importers' payoffs are increasing in the relative share $\theta_i(g^I)$ of i.

Our model represents a stylized and simplified scenario with stark predictions and this theoretical benchmark will be used to guide the empirical analysis done in Section 4. It is worth noting that the solution represents an equilibrium situation and, additionally, the model takes prices and other exogenous characteristics of the market as constant. So it cannot account for price fluctuations or for other exogenous shocks.[20]

A first important prediction is that, consistently with the literature on importing and productivity, the higher a firm's involvement in importing is, the higher her payoff will be. In the model the degree of participation of a firm in importing can be described by the share of its relations with other importing firms, i.e. the relative degree. The relative degree, which takes into account the extensive margin of a firm's trades, is a sufficient statistics to pin-down the "internationalization intensity" of a firm.[21] However, in order to exploit all the information available in the data and for comparability with the extant literature on importing (see for example Kasahara and Rodrigue, 2008 and Tintelnot et al., 2017), in the empirical part of the paper our preferred proxy of the degree of involvement of a firm in importing will be the share of imported bovines in the total number of bovines used in production, which takes into account both the extensive and the intensive margins of a firm's trades. In the robustness checks in Section 4.3 we show that the main results are robust to using the relative (in)degree.[22]

The second crucial prediction of the model that we aim to put under scrutiny is related to the role of "network closure". On the one hand, in equilibrium importers establish a network of trade linkages among them characterized by being "supported", because only supported links guarantee non-negative payoffs. Moreover, each link between two importers is supported by another importer. On the other hand, the degree of closure of the relations involving domestic inputs is not relevant to determine the payoffs. In practice, in the data we observe that, although the links between importers are much more supported than those among non-importers, not all links among importers are supported. Following the main message of the model, we expect that the payoffs stemming from importing will be increasing in the percentage of an importer's links that are supported and, instead, the percentage of supported links of a non importer will be not relevant for determining her performance.

In this light, the empirical section will aim to study whether the available evidence is consistent with the following main qualitative predictions of the model:

(P1) the higher is a farm involvement in importing, as proxied by the share of imported bovines, the higher will be its productivity (from Proposition 2);
(P2) the effect of importing on productivity is heterogeneous and positively depends on the proportion of supported links of the farm (from Proposition 1);
(P3) the proportion of supported links of a farm is not a relevant determinant of productivity for farms that use only traditional domestic bovines (from Proposition 1).

Predictions P2 and P3 follow from the first two points in the statement of Proposition 1. They refer to the role of the proportion of supported links for importing and non-importing farms, respectively. For the latter, the model predicts that the proportion of supported links is not a relevant determinant of firm performance, while for the former, our theory suggests that firm performance will increase in the percentage of supported links.

3. Background and data description

The data on the movements of bovines are provided by the Italian National Animal Identification and Registration Database (*Anagrafe Bovina*) managed by the Italian Ministry of Health. The Registration Database was developed after the introduction of the EEC-issued Council Directive 92/102/EEC in 1992. This Directive aimed at regulating beef cattle movements and guaranteeing their traceability after the outbreak of bovine spongiform encephalopathy (a.k.a. mad cow disease).

The dataset tracks the movements of each bovine from birth until slaughtering. Incoming animals from foreign countries are also registered in the database. Each animal is assigned a unique identification code and, moreover, the dates and the geographical locations of origin and destination of each of its movements are recorded in the database. The data, thus, enable the identification of the links between all possible animal holdings and, in particular, between animal husbandry or farms and slaughterhouses. Given the epidemiological interest in identifying all potential channels of infection, the dataset defines a *holding* as a closed structure where animals are somehow isolated from other livestock (Muscillo et al., 2021).

Structures identified as animal husbandries or farms can thus be considered as single production units. Stables, for efficiency reasons, usually house bovines of the same age and breed. Independently of

[20] Refer to Section 3 for more details on how price fluctuations and other exogenous variations may influence the cattle market under analysis.

[21] In the model, c_{ij} and v_{ij} describe the differences in costs and quantity traded for importing firms. However, there is not enough information about intensive margins because for tractability reasons the payoffs deriving from trade in domestic intermediate inputs are normalized to 0.

[22] The use of the indegree instead of the degree is due to the mechanical correlation with the dependent variable used, as explained in Section 4.1.

the breed, beef production is roughly divided in three stages (cow–calf stage, stock-calf stage, feedlot stage) (Field, 2017), so the transfer of bovines from one farm to another (or to a slaughterhouse) can be seen as the completion of a production stage. In this context, the number of bovines exiting from a farm, conditional on the number of past inflows, can be used as a measure of productivity, reflecting the survival, especially at earlier ages, of the reared animal and its ability to grow. Indeed, inflows of bovines into a farm do not necessarily translate into outflows if the fattening stage is not successfully conducted and the animal is not matched with adequate environmental conditions. Bad conditions and/or stress suffered by the bovine may considerably hamper its growth or even lead to the development of diseases (Field, 2017).[23] Holdings registered as farms will thus represent the main unit of analysis in our empirical investigation and movements from farms towards other farms or slaughterhouses will be used to infer differences in technical productivity of premises. It is worth noting that our measure of efficiency is based on the actual quantities traded by firms and is not revenue-based.

Additional information about the breed of each animal allows us to restrict our sample only to breeds that can be used for meat production; cattle for dairy production are excluded from the sample, whereas dual-purpose meat–milk breeds and cattle classified as crossbreeds are included.

We focus our analysis on cattle movements in the Piedmont region. Together with Veneto and Lombardy, Piedmont is one of the main producers of beef in Italy (Sarzeaud et al., 2008; Rama, 2008, 2009, 2010, 2011, 2012). Differently from the other northern regions, which are mainly specialized in fattening imported calves, beef farming in Piedmont is characterized by a diversified productive system.[24] On the one hand, local farmers raise native breeds (i.e. the Piedmontese), thus maintaining active a local suckler-cow system. On the other hand, Piedmont imports 53% of livestock, which means that several farmers are also involved in fattening foreign breeds. The proximity to the French border facilitates the imports. For farms located farther from the border the choice of importing bovines from foreign countries is heavily affected by problems related to the stress induced by the longer transport. These problems include the development of diseases and reduced growth (or even death) of the animal in the receiving fattening farms. Long transport is also more costly since, due to the current European legislation, bovines cannot be transported for more than eight hours. Long movements of animals, especially from foreign countries, are thus required to transit through specific holdings, called staging point, to give rest to the animals for at least 24 h. Due to the shorter distance from the border, transits through staging point is a limited phenomenon for receiving farms located in Piedmont, and this simplifies both the identification of connections between farms and also the analysis of the determinants of the adoption of foreign breeds.

We start from the original directed network of cattle transactions that we observe, and we construct an undirected network of owners in the following way. To construct the network statistics describing the social network of owners, we use both information on movements between holdings and information on farms' ownership. The data contains information on how much time an owner has kept a given number of bovines in each farm. The structures/holdings registered in the database cannot be considered directly as nodes of the ownership network, because two or more stages of production can be implemented in farms all belonging to the same owner.

Fig. 3 illustrates this with an example. The supply chain is represented by a production network, in the bottom layer, where nodes are farms and directed links are exchanges of animals from the origin holding to the destination holding. Notice that the production network allows directed loops for 2 reasons: (i) exchanges are considered in a 12-month time window, so it may be that farm F sends to farm G and I in a given date and then, less than 12 months later, G also sends animals to I; (ii) animals may simply be moved from a holding to another, thus between two holdings both doing the same production phase. The above layer in Fig. 3 represents the induced ownership network: each holding is associated with its owner and a link between two owners is established if there has been at least one exchange of animals from at least one holding of the first owner to one holding of the second owner in the past 12 months. Links in the top layers are not directed to stress that social relationships are considered as symmetric and reciprocal, because we proxy social interactions with the observed transactions. Notice that support is measured in the top layer. This implies that, since holdings belonging to the same owner correspond to the same node in the ownership network, the presence of an owner in several production stages cannot determine a closed triangle, i.e., supported links (see owner 4 and holdings F, G and I in Fig. 3). Moreover, notice that triangles present in the ownership network may not correspond to any loop in the production network (as in the case of owners 1, 2 and 3) and viceversa (as for holdings B, D and H).

Similarly, by focusing on ownership, we can detect connections between supply chains that could not be identified if we were using structures/farms as unit of analysis. Panel (a) of Fig. 4 represents a case where: owner 1 owns farms A and B, owner 2 owns D and G and owner 3 owns C and H. There is no movement of bovines between any two structures belonging to the same owner. The network structure based on ownership in top layer, where holdings A and B (as well as D and G and C and H) are grouped in a unique owner node, allows us to identify two closed triangles (1, 2, 3) and (1, 3, 5) thus detecting supported links. The latter could not be identified if nodes A and B were considered as separate structures. If a farm hosts simultaneously bovines of different owners, then we assign the links corresponding to this holding to each of the owners present in that structure.

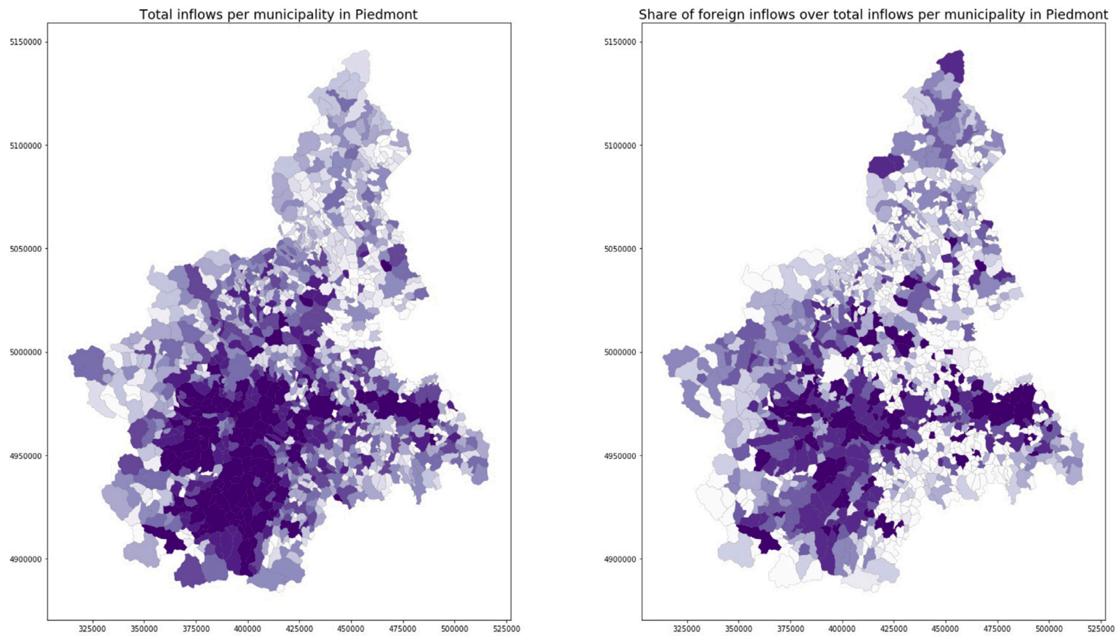
Our final network is thus characterized by owner-specific nodes. For each node we compute several ego/local-network measures such as degree, proportion of supported links, centrality, clustering, betweenness, and so on. For the computation of these measures we have used the universe of farms and owners in Italy. Then, these owner-specific network measures are assigned to the corresponding farm which will be the unit of analysis in our empirical investigation. When more owners coexist in the same farm, we assign to that holding the maximum of the given network measure. In almost all of the cases this maximum value belongs to the owner with the highest number of bovines in the farm.

Our dataset is constructed using the information available for the 2006–2013 period. We have implemented some trimming procedures since some holdings, although classified as farms, display anomalous values of flows and stocks that suggest that they could be used as assembly centers and/or staging points. For these reasons we dropped all observations with a value of the stock and of the number of suppliers greater than the corresponding 99th percentile.[25] Finally, we excluded farms that have exceeded a value of inflows greater than 211 (corresponding to the 99th percentile) at least once in the 2006–2013 period.

[23] To minimize health problems, the optimal environmental conditions present in each holding should be highly breed- and age-specific, such as heating, ventilation, specific dietary requirements, sanitary conditions, space allotment, etc. Specific "financial losses related to health issues account to 62% due to death loss, 21% due to performance losses in sick cattle, and 17% for the expense of treatment" and "[t]he average sick animal shrinks 10–20%" (Field, 2017).

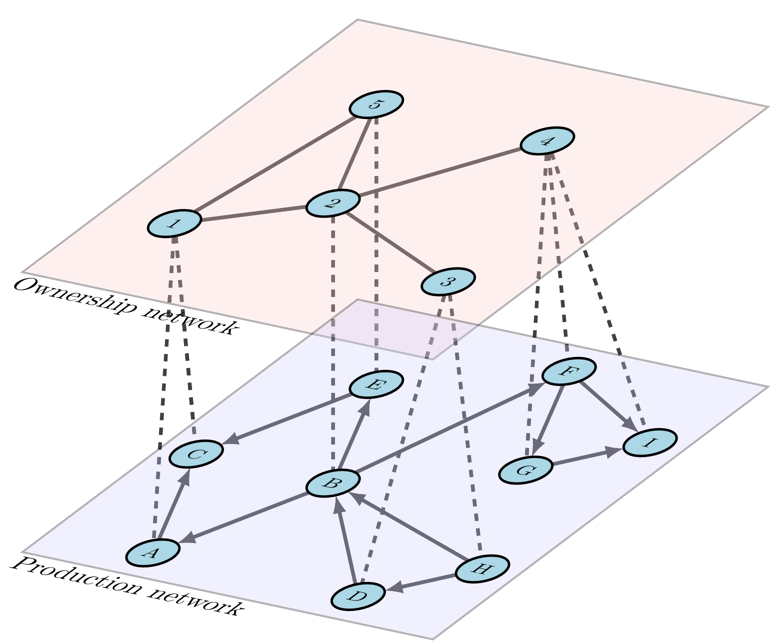
[24] In Piedmont, cattle industry is composed by many relatively small and independently-owned farms. These farms are mainly family-owned businesses where labor can be considered as a fixed input. The average farm has 580 livestock units in Piedmont, whereas in a somewhat comparable region, such as Veneto, the average value is 1250 (Rama, 2012, section 4.1).

[25] The 99th percentile of the stock is equal to 763 bovines, whereas the median and the 75th percentiles are 41 and 101 respectively. The 99th percentile for the number of suppliers (the variable $Indegree_s$ that we will later use as a control in the regression) is equal to 34. The median and the 75th percentile are 1 and 3, respectively.



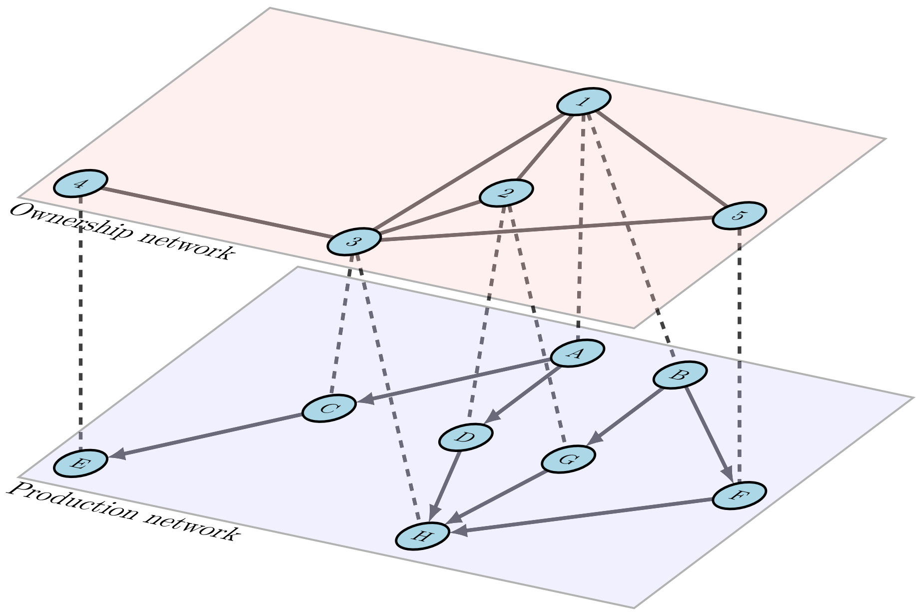
Piedmont is a region located in the north-western part of Italy and shares its western borders with France. The figure on the left shows the total inflows in each municipality and the one on the right the share of these inflows that are of foreign cattle. Darker areas correspond to larger inflows on the left and larger foreign shares on the right, respectively.

Fig. 2. Piedmont and cattle inflows.



The bottom layer describes the production network (i.e. supply chain) where the directed links are exchanges from the origin holding to the destination holding. The top layer represents the ownership network induced by the production network: dashed lines join a holding to its owner and a link between 2 owners is present if there is at least one link among their structures.

Fig. 3. Ownership Network and Production Network.



In this example, it can be seen that the relationship between owner 1 and owner 2 is supported by owner 3, although no closed triangle is present in the production network (bottom layer).

Fig. 4. Supported links between owners from seemingly unrelated supply chains.

Again, the rationale of this selection is to retain only structures whose (production) capacity is compatible with the farming activity and to exclude premises used as assembly centers and/or staging points.[26]

4. Econometric analysis

This section presents our empirical analysis to study the main predictions of the theoretical model derived in Section 2.2: a farm's performance is an increasing function of its involvement in importing; the performance of a farm that uses only traditional domestic bovines is not affected by the proportion of supported links; the effect of importing on productivity positively depends on the proportion of supported links. In Section 4.1, we present our empirical model and describe the variables used in the analysis. In Section 4.2 the main results are commented and then, in Section 4.3, we show the robustness of these results to confounding mechanisms related to the network structure, to externalities/spillovers connected to farm location and to alternative measures of involvement in importing and of network closure.

4.1. Empirical framework

Our empirical analysis uses the exact information on the number of bovines exiting from a registered farm to estimate a plant-level production function, thus avoiding omitted price bias and optimally using information at the highest level of disaggregation (Van Beveren, 2012). The following regression equation is estimated to assess the advantages of using foreign bovines and the role of the network structure in amplifying the import premium:

$$\begin{aligned} \text{OutFlow}_{it} = \beta_0 &+ \beta_1\, \text{InFlow}_{i,[t-4,t-1]} + \beta_2\, \text{Foreign}_{i,[t-4,t-1]} + \\ &+ \beta_3\, \text{Support}_{i,[t-4,t-1]} \\ &+ \beta_4 \left(\text{Foreign}_{i,[t-4,t-1]} \times \text{Support}_{i,[t-4,t-1]}\right) + \\ &+ \boldsymbol{X}_{i,[t-4,t-1]} \cdot \boldsymbol{\beta_5} + \theta_t + \upsilon_i + \varepsilon_{it}, \end{aligned} \tag{3}$$

for all farm $i = 1, \dots, N$ and quarter $t = 1, \dots, T$.

Our dependent variable, OutFlow_{it}, is the number of bovines exiting in quarter t from farm i and directed to other farms or slaughterhouses. As mentioned in Section 3, for a bovine, the exit from a farm can be considered as the completion of a production stage.[27] The outflow of bovines, conditional on the number of past inflows, can then be used as a measure of production efficiency.

The variable $\text{InFlow}_{i,[t-4,t-1]}$ measures the total number of bovines entering in farm i in the year preceding t (i.e. from quarter $t-4$ to quarter $t-1$ included). We retain in the sample only farms which have been active from $t-4$ to $t-1$, i.e. have received some animals in the previous year.[28] Our main proxy of a farm involvement in importing is the variable $\text{Foreign}_{i,[t-4,t-1]}$, which is the percentage of foreign livestock over the total inflow of bovines entered in that same period. As mentioned in Section 2.2, this variable is a more refined and a more standard proxy of the "internationalization intensity" of a firm with respect to the mere proportion of connected farms which are importers (i.e. relative degree), that is the variable on which Proposition 2 provides a prediction. Nonetheless, in Section 4.3 we show that the results are robust to using the relative indegree, which is the ratio between the number of connected providers of farm i that use foreign bovines over the total number of its providers during the year preceding t.[29]

[26] The 99th percentile of inflows is approximately 10 times the 90th percentile (22 animals) and almost four times the 95th percentile (58 bovines). The empirical results of the paper do not change if we apply more restrictive selection criteria or if we do not apply any trimming procedure.

[27] Even if the transfer of livestock occurs between two holdings belonging to the same owner.

[28] Observations of farms are excluded from the sample only when they are not receiving bovines for a year. The observations of the same farms may then be re-included in the sample if they become active again, i.e. they restart receiving bovines.

[29] The relative indegree is computed consistently with the definition given in the model and used in Proposition 2: the number of connections with other importers (independently of the origin of the cattle traded) divided by the total number of connections that a node has. In addition, notice that in the empirical analysis we use indegree and relative indegree instead of degree and relative degree, respectively, because the portion of degree due to outdegree (i.e. the number of outgoing links) is endogenous, being mechanically correlated with the number of exiting bovines, which is our dependent variable.

The choice of measuring all regressors in a one-year time window is supported by goodness-of-fit indexes and is also motivated by the need to encompass production/fattening stages of different length (from 3 to 12 months). The different time windows chosen for the measurement of the dependent and independent variables explicitly exclude fattening stages shorter than 3 months, also because these only represent a tiny portion of total fattening stages (Field, 2017).

In line with (Jackson et al., 2012), the variable $\text{Support}_{i,[t-4,t-1]}$ measures the proportion of supported links of the owner of farm i, i.e. the ratio between the number of links of the owner of farm i with owners that share a common neighbor over the total number of links of the owner of farm i. As explained in Section 3, this index is constructed using the ownership network and thus represents a measure specific to the owner of farm i.[30] The interaction between the share of foreign bovines and the measure of support is introduced to study the importance of closed and transitive relationships for importers. We compute a support index for all importers and non-importers (as opposed to creating a specific measure for the two groups or to the subgroup of importers). Since in the majority of the cases the links among importers are supported by other importers, such a "global" support index computed in this way is a good proxy of the support index computed using only the subnetwork of importers.[31] Indeed, in the prediction of our stylized model of Section 2, the support measure which is relevant for the performance of importers is that computed only within the subnetwork of importers, while having supported links of any kind is not affecting the efficiency with which domestic inputs are used.

The control variables $\boldsymbol{X}_{i,[t-4,t-1]}$ include the average age of bovines entered in farm i, which implicitly indicates the position of the production stage within the supply chain. The estimations also control for farm size, constructed using the information on the stock of bovines measured at $t-4$ before any inflow or outflow of bovines in that quarter. Additional network measures are included and discussed at the end of this section.

Lastly, υ_i captures farm-specific fixed effects, i.e. time invariant unobserved attributes related to the production structure such as geographic location or owner-specific attributes, while θ_t represents time dummies measured on a quarterly basis from 2007Q1 to 2013Q4.

In our basic specification the error term ε_{it} may include omitted inputs such as labor and capital.[32] The omission of inputs correlated with regressors – that is, correlated with inflow of bovines or share of foreign bovines – would lead to inconsistent estimates. In the Italian beef farming system, however, capital (e.g. facilities and equipment) and labor can both be considered as fixed costs (Rama, 2012).[33] These two cost items, although not negligible in absolute terms, represent a minor portion of total expenses.[34] Moreover, in Piedmont the farming system is characterized by labor almost entirely provided by the family (Sarzeaud et al., 2008; Rama, 2008, 2009, 2010, 2011, 2012). Hence, by focusing on highly disaggregated structures with a given level of production capacity, we can consider the amount of fixed capital and family labor used in each farm as time-invariant and, crucially, we can assume that the contribution of these omitted inputs is captured by structure-specific fixed effects.

Other unobserved time varying characteristics inside the error term may be potentially correlated with the inflow of bovines and the portion of foreign animals purchased by the farm. However, the size

Table 1
Descriptive statistics.

	(1) Foreign = 0	(2) Foreign > 0	(3) Total
Outflow	5.594 (10.29)	25.65 (32.91)	9.408 (18.80)
Foreign	0 (0)	76.40 (32.27)	14.53 (33.12)
Relative Indegree	0.138 (0.284)	0.769 (0.307)	0.258 (0.380)
InFlow	14.12 (29.15)	103.0 (118.5)	31.03 (67.65)
Mean Age	15.30 (23.85)	18.05 (18.27)	15.82 (22.92)
Size ≤ 30	0.495 (0.500)	0.225 (0.417)	0.444 (0.497)
30 < Size ≤ 100	0.328 (0.470)	0.382 (0.486)	0.339 (0.473)
Size > 100	0.177 (0.381)	0.393 (0.488)	0.218 (0.413)
Support	0.175 (0.303)	0.300 (0.398)	0.199 (0.327)
Transitivity	0.0383 (0.136)	0.0645 (0.189)	0.0433 (0.148)
Eigen Centrality	0.00112 (0.0115)	0.00351 (0.0284)	0.00157 (0.0162)
Betweenness	364 336.9 (3 476 988.3)	895 497.4 (4 637 422.3)	465 349.7 (3 731 416.4)
Closeness	0.110 (0.0306)	0.0897 (0.0643)	0.106 (0.0401)
Indegree	2.011 (4.639)	3.481 (7.603)	2.291 (5.362)
Indegree_s	3.609 (4.502)	3.952 (5.276)	3.674 (4.661)
Number of observations	105 820	24 850	130 670

Descriptive statistics on the final sample of 10,656 farms used for estimation. Means and Standard errors in parenthesis. Column 1 reports the descriptive statistics for farms who are not using foreign bovines. Column 2 refers to farms that received at least one foreign bovine. Column 3 reports the statistics for the entire sample used for estimations. In two-tailed tests for the difference between the means in 1 and 2, the equality of the means is rejected for all the variables with p-values < 0.001. The statistics for the variable Outflow refer to time t, whereas all the other descriptive statistics on the independent variables are computed on a yearly basis in the quarters $[t-4, t-1]$. Indegree is the indegree index in the network constructed using the information on ownership. Indegree_s is the number of holdings (structures) sending bovines to farm i. Closeness (computed as in Newman 2003) is multiplied by 10^9 for scaling purposes. Additional information on within-structure variability can be found in Table A1 in the Supplementary Information.

Table 2
Correlation among main variables.

	Foreign	Relative indegree	Support	Transitivity
Foreign	1			
Relative indegree	0.686	1		
Support	0.098	0.090	1	
Transitivity	0.046	0.050	0.520	1

Correlations are calculated for the sample used in the main analysis (the number of observations is 130 670).

[30] When farm i hosts simultaneously bovines of different owners, the variable takes the maximum value of the proportion of supported links taken across the different owners of bovines in that farm.

[31] More precisely, a generic link between two importers is supported by a generic firm or by another importer in 41.29% or 38.4% of the times, respectively. Whereas a link between two non-importers is supported (by any firm) only 15.95% of the times.

[32] As shown and explained in more detail in the Supplementary Information, we have also addressed potential correlation in the error terms of geographically adjacent farms by (i) clustering standard errors at the municipality level; ii) allowing spatial correlation by adopting (Conley, 1999, 2010)'s approach; iii) checking that network ties between farms do not predict differences in residuals.

[33] Hereafter, the main references on production inputs and input price dynamics are (Sarzeaud et al., 2008; Rama, 2008, 2009, 2010, 2011, 2012). Additional references and details can be found in the Supplementary Information.

[34] The purchase cost of the animal and feeding cost represent the greater portion of total expenses (Sarzeaud et al., 2008; Rama, 2008, 2009, 2010, 2011, 2012).

of production and, in particular, the share of foreign bovines, is mainly affected by the level of input prices. The latter, in the period under observation, have been subject to wide fluctuations determined by exogenous shocks. Feed prices have been experiencing huge increases and variations due to the price bubble related to bio-fuel production.[35] Variations in weather conditions contributed to the volatility in the production of home-grown feed. Most importantly, the adoption of foreign breeds has been widely affected by both the block of imports due to the spread of blue tongue disease in Northern Europe and the fluctuations in the price of young bovines (*broutards*) coming from France.[36] With structure fixed effect capturing omitted fixed inputs, and with most of the variation in regressors (i.e. inflows) being determined by unpredictable shocks, we can assume, as conventionally done in the context of the estimation of a production function of an agricultural product (Aguirregabiria, 2009), that the assumptions of fixed effect regressions are satisfied.

For Piedmontese farms, mostly family-run, it is unlikely that time varying changes in productivity are associated with the adoption of unobserved inputs other than the breed-specific investment in know-how, faced to take advantage of the superior genetic growth potential of foreign breeds. Indeed, since the main innovation is the adoption of foreign breed itself, our aim is to capture the heterogeneity in productivity gains potentially associated with the effect of network characteristics. Among these, given the predictions of the model, network closure in particular can help recovering this sunk investment by ensuring sustainable and profitable trade relationships in the future.

However, in principle, other unobserved factors affecting productivity and related to the network structure could be associated with increases in imports. Importing firms may undertake productivity-enhancing investments in know-how and structures and, simultaneously, may intensify connections with each other. If this were the case, the estimated coefficient associated with the interaction of import intensity and the percentage of supported links could be contaminated by this alternative channel. To take, at least in part, into account this possible confounding mechanism, in the robustness checks, we introduce as an additional explanatory variable the transitivity coefficient (a.k.a. clustering) and its interaction with the import share, which is an alternative measure of network closure around a node i. It is defined as the number of existing edges between the neighbors of node i divided by the number of all possible edges between the neighbors of node i. The main difference between transitivity and support in the undirected network of owners (please refer to the discussion in Section 3 for a distinction between the network of owners and the network of farms) is that the former describes the extent to which contacts of node i are also in contact with each other, thus capturing both the intensity of interconnections in i's neighborhood and the closure of triplets originating from i. Whereas the latter isolates only the closure aspect of connections since it counts the neighbors that share at least one neighbor with i (Jackson et al., 2012). Therefore, if the heterogeneity of the import premium were, at least in part, a consequence of an increase in the clustering of highly productive firms investing in complementary assets, this would be, at least in part, controlled for by including the transitivity coefficient and its interaction with the import share as additional explanatory variables in Eq. (3).

Table 1 reports some descriptive statistics (i.e. average and standard deviation) of the dependent and independent variables used in the analysis, for the subsample of farms using only livestock born in Italy (column 1), structures receiving at least one foreign bovine (column 2) and the entire sample of farms (column 3). Holdings breeding foreign livestock are larger than farms housing only domestic bovines. There are not marked differences in the mean age of cattle transiting through the two different types of premises. Farms receiving imported animals display, however, inflows and outflows that are much larger than the corresponding values for the other holdings. These results are in line with the literature showing that importers are larger and exhibit significant performance premia relative to non-importing firms (Bernard et al., 2009; Castellani et al., 2010). Together with the proportion of supported links, which is 30% for farms using foreign breeds and 17% for holdings using domestic animals, these variables are used in the baseline specification (i.e. Eq. (3)) whose estimates are presented in Section 4.2.

In addition to support and transitivity, other local network characteristics are described using four standard concepts of centrality, as different measures capture different aspects of the position of a node in a network and their interpretation may strongly depend on the context (Jackson et al., 2017). Specifically, we consider the following: "connectivity", the number of (direct) links of a node, which we measure with the indegree of a node; "closeness", the reciprocal of the sum of the length of the shortest paths from the node to all other nodes, which describes how close an agent is to all other agents and, hence, the easiness to access information; "intermediation" (a.k.a. the betweenness), the number of shortest paths between any two nodes passing through the owner of farm i, which captures the ability to broker connections between otherwise disconnected parts of the network; and "having well-connected neighbors", which captures a node's ability to connect with other well-connected nodes and is measured by the eigenvector centrality. These centrality statistics are used as additional explanatory variables in the robustness checks presented in Section 4.3. As shown in Table 1, with the exception of closeness, all other networks measures (support, transitivity, eigenvector centrality, betweenness and indegrees) exhibit higher values for farms breeding foreign livestock, thus indicating that importing firms usually tend to be better connected and embedded within the production network.

Finally, we also report the average value of the relative indegree (defined above) which is, as expected, relatively higher for farms using foreign bovines. This is not surprising, indeed, since this alternative proxy of involvement in importing is highly correlated with the variable Foreign (i.e. the Pearson correlation coefficient is 0.686, as shown in Table 2).[37]

4.2. Main results

In this section we present the empirical results obtained by estimating Eq. (3) with different sets of control variables and for different samples.

In the first column of Table 3, we report the results for a specification in which we control for: the total number of bovines entering in farm i during the year preceding t (i.e. from quarter $t-4$ to quarter $t-1$ included), quarter fixed effects and production-unit fixed effects.

For a farm with no supported links, we estimate that an increase of 10 points in the percentage of foreign livestock (over the total inflow of bovines entered in the same period) is associated with a rise in the number of bovines exiting the farm of approximately 0.16 which, compared with the observed average of the dependent variable (i.e., 9.4), corresponds to an economically (and statistically) significant effect of 1.7%. By looking at the estimated coefficient associated with the interaction between the support index and the share of foreign cattle, it is apparent that network closure is a fundamental determinant

[35] See the Supplementary Information for references and details.

[36] Price fluctuations were mainly driven by exogenous factors such as variation of the internal demand in France or increased exports towards Turkey and other Southern Mediterranean countries (Rama, 2012). See the Supplementary Information for references and details.

[37] If the relative degree were computed by counting only the links involving the trade of foreign breeds over the total number of links that one has (see footnote for the actual definition), this would result in an even higher correlation coefficient with the proportion of foreign cattle used in production (i.e. 0.94).

Table 3
Main results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Foreign	0.016***	0.016***	0.016***	0.014***	0.012***	0.020***	0.017***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
InFlow	0.108***	0.108***	0.108***	0.113***	0.109***	0.114***	0.110***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Support	−0.164	−0.155	−0.150	−0.068	−0.014	−0.048	0.012
	(0.115)	(0.114)	(0.114)	(0.112)	(0.175)	(0.118)	(0.189)
Support × Foreign	0.023***	0.023***	0.023***	0.021***	0.013**	0.023***	0.014**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Mean Age		−0.005***	−0.005***	−0.004***	−0.003*	−0.005***	−0.004*
		(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
$30 < \text{Size} \leq 100$			0.312***	0.299***	0.361***	0.294***	0.343***
			(0.086)	(0.086)	(0.119)	(0.092)	(0.131)
$\text{Size} > 100$			0.674***	0.650***	1.182***	0.675***	1.264***
			(0.136)	(0.137)	(0.195)	(0.148)	(0.217)
Indegree_s				−0.137***	−0.091**	−0.131***	−0.077**
				(0.029)	(0.036)	(0.030)	(0.037)
Constant	5.208***	5.271***	5.026***	5.459***	6.481***	5.418***	6.484***
	(0.225)	(0.223)	(0.230)	(0.224)	(0.351)	(0.237)	(0.380)
R^2	0.742	0.742	0.742	0.742	0.773	0.743	0.774
N	130 670	130 670	130 670	130 670	76 844	122 013	70 114

All specifications include quarterly dummies and farm fixed effects. Clustered standard errors at the farm level in parenthesis. Indegree_s is the number of holdings (structures) sending bovines to farm i.
***Significant at 1%.
**Significant at 5%.
*Significant at 10%.

of the heterogeneity of the import effect. In fact, for a production unit whose links are all supported (i.e. the Support variable is 1), the effect of an increase of 10 points in the percentage of foreign livestock is estimated to be around 4.1%. This evidence is consistent with our model (Prediction P1 at page 13), and with the literature finding a positive effect of imported inputs on firms' performance, but it also suggests that such effect is heterogeneous depending on the closure of the network in which production units are embedded (Prediction P2). In addition, (as from Prediction P3) support, which is a proxy of trust between firms, has no statistically significant effect for firms using only domestic intermediate inputs, as shown by the estimated coefficient for the support index (when not interacted with Foreign).

In the second column of Table 3, we additionally control for the average age of bovines entered in farm i to take into account that farms are specialized in different stages of the production chain (which are defined by specific age of the bovines) characterized by different fattening times. The results shown in the third column (of Table 3) are obtained by introducing in the previous specification also size dummies (defined using the observed stock of bovines at the beginning of $t-4$) in order to take into account possible economies of scale related to the use of imported bovines. In the fourth column, we present the estimates obtained by additionally controlling for the number of holdings (including structures different from farms) providing bovines to farm i (during the periods $t-4$ to $t-1$). We expect that the higher the number of providers the more complex will be for farmers to adjust their production techniques to the needs of the bovines. The results of these additional specifications confirm the findings of the first column.

In the last three columns we report the estimates obtained when using the specification employed in the fourth column but with different samples. In the fifth column we repeat our analysis by restricting the sample to farms whose inflows of bovines have an average age equal or greater than 6 months. This is motivated by the fact that the movements of foreign bovines may occur at different ages than domestic animals because, by definition, animals are not observed before import. Moreover, we verify whether our results are driven by peculiarities in the earlier stages of production (i.e. weaning or fattening of calves). In the sixth column, we retain in the sample only farms that are classified as meat producers. In the last column we combine these sample restrictions. The main results are still robust to these different sample definitions.

4.3. Robustness checks and alternative explanations

Both in the theoretical section and in the baseline regressions we have underlined the importance of a local pattern of the production network, the support index, in favoring cooperation and trust but also in enhancing firms' economic performance. In the following empirical analyses we consider other possible mechanisms that could foster firm efficiency and could be related to the network structure and farm location (see Table 4). We also show that the previous results are robust to using the relative indegree, instead of the share of foreign cattle, as proxy of a farm's involvement in importing (see Table 5).

In the first robustness check, already mentioned in Section 4.1, by controlling for the transitivity coefficient we investigate whether the effect of the support index on the heterogeneity of the import premium is simply a consequence of an increase in the clustering of (high productive) firms. It is worth recalling (Jackson et al., 2012) that the transitivity/clustering coefficient captures the intensity of interconnections in i's neighborhood while the support index only measures the extent to which the triplets originating from i are closed and therefore it concentrates on the closure aspect connected to trust between agents. As expected, the two network statistics are positively correlated at 68.6%, as shown in Table 2. In the first column of Table 4 we substitute the support index (and its interaction with import share) with the transitivity coefficient (and its interaction with import share). In the second column, we include both support and transitivity (and their interaction with import share). We do not find any statistically and/or economically relevant effect of the transitivity coefficient (column 1) and, most importantly, the previous results about the support index and its interaction with the share of foreign bovines continue to hold (column 2). Therefore, only the "closure" aspect of connections is important for enhancing the performances of importers, while how much their neighbors actually connect to each other is irrelevant. These findings suggest that the detected positive effect of support on importers' performance cannot be ascribed to omitted variables, such as increases in knowledge or productivity, which could be simultaneously

Table 4
Robustness checks.

	(1)	(2)	(3)	(4)	(5)	(6)
Foreign	0.021***	0.016***	0.011***	0.002	0.005	0.014***
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
InFlow	0.109***	0.108***	0.112***	0.110***	0.112***	0.110***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Transitivity	−0.273	−0.156	−0.301	−0.378	−0.312	−0.194
	(0.201)	(0.285)	(0.286)	(0.286)	(0.286)	(0.321)
Transitivity × Foreign	−0.004	−0.017	−0.018	−0.016	−0.018	−0.018
	(0.012)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Mean Age	−0.005***	−0.005***	−0.005***	−0.004***	−0.005***	−0.005**
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
30 < Size ≤ 100	0.312***	0.313***	0.298***	0.297***	0.298***	0.323***
	(0.086)	(0.086)	(0.086)	(0.087)	(0.086)	(0.103)
Size > 100	0.673***	0.675***	0.651***	0.650***	0.650***	0.692***
	(0.136)	(0.136)	(0.136)	(0.136)	(0.136)	(0.151)
Support		−0.105	0.071	0.113	0.082	−0.058
		(0.162)	(0.159)	(0.160)	(0.159)	(0.182)
Support × Foreign		0.026***	0.019***	0.017**	0.018***	0.017**
		(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Eigen Centrality			−4.023	−4.977	−4.074	−4.489
			(6.003)	(6.005)	(6.004)	(6.663)
Eigen Centrality × Foreign			0.031	0.037	0.031	0.037
			(0.239)	(0.238)	(0.238)	(0.256)
Betweenness			0.000	0.000	0.000	0.000
			(0.000)	(0.000)	(0.000)	(0.000)
Betweenness × Foreign			0.000	0.000	0.000	0.000
			(0.000)	(0.000)	(0.000)	(0.000)
Closeness			0.773	1.244	0.929	0.841
			(1.023)	(1.028)	(1.022)	(1.232)
Closeness × Foreign			−0.016	−0.033	−0.020	−0.002
			(0.042)	(0.042)	(0.042)	(0.046)
Indegree			0.006	0.006	0.005	0.014
			(0.029)	(0.028)	(0.029)	(0.031)
Indegree × Foreign			0.002*	0.002*	0.002*	0.002
			(0.001)	(0.001)	(0.001)	(0.001)
$Indegree_s$			−0.143***	−0.135***	−0.141***	−0.150***
			(0.029)	(0.029)	(0.029)	(0.032)
$Indegree_s$ × Foreign			0.000	0.000	0.000	0.000
			(0.002)	(0.002)	(0.002)	(0.002)
Spec Mun				415.234***		
				(37.667)		
Spec Mun × Foreign				2.210***		
				(0.507)		
Spec Imp Mun					13.306	
					(33.070)	
Spec Imp Mun × Foreign					1.021**	
					(0.405)	
Constant	4.998***	5.017***	5.385***	2.672***	5.278***	
	(0.232)	(0.231)	(0.233)	(0.329)	(0.287)	
R^2	0.742	0.742	0.742	0.744	0.742	0.725
N	130 670	130 670	130 670	130 670	130 670	123 927

Specifications (1)–(5) include quarterly dummies and farm fixed effects. Specification (6) contains municipality-by-quarter fixed effects and farm fixed effects. Indegree is the indegree index in the network constructed using the information on ownership. $Indegree_s$ is the number of holdings (structures) sending bovines to farm i. Clustered standard errors at the farm level in parenthesis.
***Significant at 1%.
**Significant at 5%.
*Significant at 10%.

determining an increase in import share and in the clustering of highly productive firms.[38]

[38] In other robustness checks (not reported here) we introduce as additional regressors the interaction of import share with firm size and with average age of bovines. The results remain equivalent.

A possible alternative explanation that is worth considering is whether it is the position of the owner in the input–output network to be the driver of the augmented performance and the observed heterogeneity in the gains from import. To take into account this hypothesis, we control for several local measures of centrality of the owner in the network and for the corresponding interaction of these variables with

Table 5
Additional robustness checks.

	(1)	(2)	(3)	(4)	(5)	(6)
Relative Indegree	0.433***	0.237**	0.725***	0.365	0.591**	0.702**
	(0.123)	(0.109)	(0.246)	(0.257)	(0.260)	(0.288)
InFlow	0.111***	0.110***	0.116***	0.115***	0.116***	0.114***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Transitivity	−0.212	−0.145	−0.207	−0.265	−0.211	−0.032
	(0.211)	(0.307)	(0.310)	(0.310)	(0.310)	(0.358)
Transitivity × Relative Indegree	−0.385	−1.212	−1.182	−1.088	−1.174	−1.358
	(0.885)	(1.020)	(1.009)	(1.001)	(1.009)	(1.074)
Mean Age	−0.004***	−0.004***	−0.004**	−0.004**	−0.004***	−0.004**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
$30 < \text{Size} \leq 100$	0.315***	0.316***	0.300***	0.302***	0.301***	0.324***
	(0.086)	(0.086)	(0.087)	(0.087)	(0.087)	(0.103)
$\text{Size} > 100$	0.686***	0.686***	0.653***	0.654***	0.652***	0.693***
	(0.137)	(0.137)	(0.137)	(0.136)	(0.137)	(0.151)
Support		−0.052	−0.008	0.008	−0.007	−0.164
		(0.189)	(0.187)	(0.186)	(0.186)	(0.213)
Support × Relative Indegree		1.257***	1.148**	1.070**	1.126**	1.161**
		(0.470)	(0.467)	(0.467)	(0.467)	(0.523)
Eigen Centrality			−4.777	−6.062	−4.905	−3.434
			(7.562)	(7.570)	(7.558)	(8.578)
Eigen Centrality × Relative Indegree			7.958	9.032	8.199	5.224
			(17.124)	(17.082)	(17.137)	(18.398)
Betweenness			0.000	0.000	0.000	0.000
			(0.000)	(0.000)	(0.000)	(0.000)
Betweenness × Relative Indegree			0.000	0.000	0.000	0.000
			(0.000)	(0.000)	(0.000)	(0.000)
Closeness			1.260	1.496	1.418	1.089
			(1.665)	(1.667)	(1.656)	(2.010)
Closeness × Relative Indegree			0.281	0.381	0.273	1.138
			(2.623)	(2.634)	(2.626)	(3.119)
Indegree			0.052*	0.053*	0.052*	0.058*
			(0.030)	(0.030)	(0.030)	(0.033)
Indegree × Relative Indegree			−0.034	−0.038	−0.036	−0.034
			(0.050)	(0.050)	(0.050)	(0.055)
Indegree_s			−0.107***	−0.104***	−0.106***	−0.112***
			(0.028)	(0.028)	(0.028)	(0.031)
Indegree_s × Relative Indegree			−0.354***	−0.352***	−0.359***	−0.397***
			(0.115)	(0.114)	(0.115)	(0.124)
Spec Mun				439.135***		
				(38.586)		
Spec Mun × Relative Indegree				68.531***		
				(17.945)		
Spec Imp Mun					51.959	
					(33.811)	
Spec Imp Mun × Relative Indegree					27.901	
					(18.491)	
Constant	5.147***	5.147***	5.299***	2.544***	5.023***	
	(0.232)	(0.231)	(0.264)	(0.361)	(0.318)	
R^2	0.742	0.742	0.742	0.744	0.742	0.725
N	130 670	130 670	130 670	130 670	130 670	123 927

Specifications (1)–(5) include quarterly dummies and farm fixed effects. Specification (6) contains municipality-by-quarter fixed effects and farm fixed effects. Indegree is the indegree index in the network constructed using the information on ownership. Indegree_s is the number of holdings (structures) sending bovines to farm i. Clustered standard errors at the farm level in parenthesis.
***Significant at 1%.
**Significant at 5%.
*Significant at 10%.

the share of foreign bovines.[39] In the third column of Table 4 we report the estimates from this robustness check. The previous results remain unaltered, and all forms of centrality are statistically non-significant. This suggests that it can be safely excluded that firms' performances are relevantly determined by other information-related mechanisms, such as knowledge spreading or information flowing in the network (as captured by closeness and indegree centrality), or nodes acting as gatekeepers in intermediation with others (as reflected by betweenness centrality), or being strategically connected to key-players in the network (as proxied by eigenvector centrality).

In the fourth column of Table 4 we take into account also the possible role of Marshallian externalities (i.e. external economies of scale)

[39] Given farm i, the centrality of its owner(s) is computed in the network of owners, that is the ownership network shown in Figs. 3 and 4.

by controlling for the specialization of the municipality in the cattle industry as proxied by the share of bovines traded in the municipality over the total number of bovines traded in Piedmont (per quarter) (i.e. the variable Spec Mun). In the fifth column we consider possible spillovers between importers by adding a proxy for the specialization of the municipality in foreign cattle: the share of farms using foreign bovines in the municipality over the total number of farms using foreign bovines in Piedmont (per quarter) (i.e. the variable Spec Imp Mun). The introduction of this explanatory variable allows us to control, at least at the local level, for unobserved factors which may have simultaneously fostered the adoption of foreign breeds and affected the structure of the production network. Finally, in the sixth column we introduce municipality-by-quarter fixed effects, which pick up all the productivity and demand shocks common to the firms located in the same municipality, such as weather conditions, infectious diseases, input prices, knowledge flows, consumers' preferences and so on. Also in this case the basic results remain unaltered.[40]

Lastly, using the same specifications presented in Table 4, in Table 5 we report the results obtained by substituting the percentage of foreign bovines (i.e. the variable Foreign) with the ratio between the number of connected providers of farm i that use foreign bovines over the total number of its providers (i.e. the variable Relative Indegree). As explained in Sections 2.2 and 4.1, the relative indegree is the measure of importing activities suggested by our theoretical model in which only the extensive margin of importing matter (i.e. the number of trade partners that are importing). The results of Table 5 are very similar to those obtained in Table 4. According to the most demanding specification (column 6, with municipality-by-quarter fixed effects), for a farm with no supported links a rise of 0.10 in the proportion of connected providers that use foreign bovines is associated with an increase in the number of bovines exiting the farm of approximately 0.07. Compared with the observed average of the dependent variable (i.e. 9.4), this figure corresponds to an economically (and statistically) significant effect of 0.8%. For a production unit whose links are all supported (i.e. the Support variable is 1), the effect of an increase of 0.10 in the relative indegree is estimated to be around 2%. Also this measure confirms that a farm's performance is increasing in its degree of involvement in importing and that this import effect positively depends on the fraction of its supported links.

5. Conclusions

This paper contributes to evaluate the "advantages of structural embeddedness" (Polidoro Jr. et al., 2011) by studying firm performance (Borgatti and Li, 2009) in the production of a homogeneous good that requires a sequential supply chain. We show that when business relationships are characterized by relatively high uncertainty, the aspect of embeddedness that matters the most for firms' efficiency is social network closure.

We adapt to firm-to-firm networks a reasoning already applied to person-to-person networks and measure social network closure as the proportion of "supported relationships" (those relationships between two agents characterized by the existence of a third common partner) that an economic agent possesses. This is a network measure related to – but different from – local clustering and has been shown to be key for establishing trustworthy relationships (Jackson et al., 2012).

We show that trust among business partners is fundamental to mitigate the typical problems arising when information is uncertain and asymmetric, quality is unobserved and, therefore, contracts are incomplete. Indeed, the heterogeneity of performance gains commonly observed in firms that use high-risk high-quality imported inputs can be explained by their ability of sustaining trustworthy/supported trade relationships with their partners. Social network closure is instead an irrelevant determinant of the performance of firms using the traditional domestic inputs, for which problems of asymmetric information and unobserved quality are much less relevant.

Our sectoral case study shows that in a developed economy, where institutions are not a major obstacle to access information and services, local characteristics of the network structure related to trust are a key factor in explaining the benefits of adopting an advanced imported input. From a policy perspective, this can be even more important for developing economies where, due to the lack of well-functioning institutions, business relationships are often characterized by informal agreements and the adoption of advanced inputs from abroad represents the main channel of technological progress.

Acknowledgments

We acknowledge funding from the Italian Ministry of Education "Progetti di Rilevante Interesse Nazionale" (PRIN) grant 2017ELHNNJ. We are grateful to the Italian Ministry of Health, Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise "G. Caporale" and, in particular, to Luigi Possenti and Diana Palma for their help with the data. We would like to thank for their helpful comments and suggestions Matteo Bizzarri, Davide Castellani, Alberto Dalmazzo, Beata Javorcik, Pau Milan, Andreas Moxnes, Francesco Nava, Adam Szeidl, Marco Tortoriello, Gergely Horvath, the participants at the seminars held at the University of Siena, University of Florence and University of Turin, at the NETEF 2018 Workshop, at the 11th ISGEP Workshop and at the 2019 conference "Economics of Global Interactions" held in Bari. We are also indebted to Marco Niccolucci for the invaluable insights on beef farming.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.socnet.2023.01.004.

References

Aguirregabiria, V., 2009. Econometric issues and methods in the estimation of production functions.
Ali, S.N., Miller, D.A., 2016. Ostracism and forgiveness. Am. Econ. Rev. 106 (8), 2329–2348.
Batjargal, B., 2007. Network triads: Transitivity, referral and venture capital decisions in China and Russia. J. Int. Bus. Stud. 38 (6), 998–1012.
Baum, J.A., Cowan, R., Jonard, N., 2010. Network-independent partner selection and the evolution of innovation networks. Manage. Sci. 56 (11), 2094–2110.
Bellamy, M.A., Ghosh, S., Hora, M., 2014. The influence of supply network structure on firm innovation. J. Oper. Manage. 32 (6), 357–373.
Bernard, A.B., Jensen, J.B., Schott, P.K., 2009. Importers, exporters and multinationals: a portrait of firms in the US that trade goods. In: Producer Dynamics: New Evidence from Micro Data. University of Chicago Press, pp. 513–552.
Bernard, A.B., Moxnes, A., Saito, Y.U., 2015. Production Networks, Geography and Firm Performance. National Bureau of Economic Research.
Board, S., 2011. Relational contracts and the value of loyalty. Am. Econ. Rev. 101 (7), 3349–3367.
Borgatti, S.P., Li, X., 2009. On social network analysis in a supply chain context. J. Supply Chain Manage. 45 (2), 5–22.
Carvalho, V.M., Voigtländer, N., 2014. Input Diffusion and the Evolution of Production Networks. National Bureau of Economic Research.
Castellani, D., Serti, F., Tomasi, C., 2010. Firms in international trade: Importers' and exporters' heterogeneity in Italian manufacturing industry. World Econ. 33 (3), 424–457.
Coleman, J.S., 1988. Social capital in the creation of human capital. Am. J. Sociol. 94, S95–S120.
Coleman, J.S., 2000. Social capital in the creation of human capital. In: Knowledge and Social Capital. Elsevier, pp. 17–41.
Conley, T.G., 1999. GMM estimation with cross sectional dependence. J. Econometrics 92 (1), 1–45.
Conley, T.G., 2010. Spatial econometrics. In: Microeconometrics. Springer, pp. 303–313.

[40] In the Supplementary Information, we augment the specification of the sixth column by adding owner fixed effects. We use two-way clustering for standard errors (at the farm and owner levels). We also report the estimation results obtained by inserting the network indices one by one. The main results do not change.

Dall'Asta, L., Marsili, M., Pin, P., 2012. Collaboration in social networks. Proc. Natl. Acad. Sci. 109 (12), 4395–4400.
Field, T., 2017. Beef Production and Management Decisions, sixth ed. Pearson Prentice Hall.
Granovetter, M., 1985. Economic action and social structure: The problem of embeddedness. Am. J. Sociol. 91 (3), 481–510.
Granovetter, M., 1992. Problems of explanation in economic sociology. Netw. Organ. Struct. Form Action 25–56.
Gulati, R., 1995. Social structure and alliance formation patterns: A longitudinal analysis. Adm. Sci. Q. 619–652.
Gulati, R., 1998. Alliances and networks. Strateg. Manage. J. 19 (4), 293–317.
Gulati, R., Gargiulo, M., 1999. Where do interorganizational networks come from? Am. J. Sociol. 104 (5), 1439–1493.
Halpern, L., Koren, M., Szeidl, A., 2015. Imported inputs and productivity. Am. Econ. Rev. 105 (12), 3660–3703.
Jackson, M.O., Rodriguez-Barraquer, T., Tan, X., 2012. Social capital and social quilts: Network patterns of favor exchange. Amer. Econ. Rev. 102 (5), 1857–1897.
Jackson, M.O., Rogers, B.W., Zenou, Y., 2017. The economic consequences of social-network structure. J. Econ. Lit. 55 (1), 49–95.
Karlan, D., Mobius, M., Rosenblat, T., Szeidl, A., 2009. Trust and social collateral. Q. J. Econ. 124 (3), 1307–1361.
Kasahara, H., Lapham, B., 2013. Productivity and the decision to import and export: Theory and evidence. J. Int. Econ. 89 (2), 297–316.
Kasahara, H., Rodrigue, J., 2008. Does the use of imported intermediates increase productivity? Plant-level evidence. J. Dev. Econ. 87 (1), 106–118.
Krackhardt, D., 1999. The ties that torture: Simmelian tie analysis in organizations. Res. Sociol. Organ. 16 (1), 183–210.
Muscillo, A., Pin, P., Razzolini, T., 2021. Spreading of an infectious disease between different locations. J. Econ. Behav. Organ. 183, 508–532.
Newman, M.E.J., 2003. The structure and function of complex networks. SIAM Rev. 45, 167–256.
Nooteboom, B., 1999. The triangle: roles of the go-between. In: Corporate Social Capital and Liability. Springer, pp. 341–355.
Polidoro Jr., F., Ahuja, G., Mitchell, W., 2011. When the social structure overshadows competitive incentives: The effects of network embeddedness on joint venture dissolution. Acad. Manage. J. 54 (1), 203–223.
Putnam, R.D., 2000. Bowling alone: America's declining social capital. In: Culture and Politics. Springer, pp. 223–234.
Rama, D., 2008. Il Mercato Della Carne Bovina. Rapporto 2008. In: Studi di economia agroalimentare, Smea-Università Cattolica del Sacro Cuore - diretta da R. Pieri, Franco Angeli Edizioni.
Rama, D., 2009. Il Mercato Della Carne Bovina. Rapporto 2009. In: Studi di economia agroalimentare, Smea-Università Cattolica del Sacro Cuore - diretta da R. Pieri, Franco Angeli Edizioni.
Rama, D., 2010. Il Mercato Della Carne Bovina. Rapporto 2010. In: Studi di economia agroalimentare, Smea-Università Cattolica del Sacro Cuore - diretta da R. Pieri, Franco Angeli Edizioni.
Rama, D., 2011. Il Mercato Della Carne Bovina. Rapporto 2011. In: Studi di economia agroalimentare, Smea-Università Cattolica del Sacro Cuore - diretta da R. Pieri, Franco Angeli Edizioni.
Rama, D., 2012. Il Mercato Della Carne Bovina. Rapporto 2012. In: Studi di economia agroalimentare, Smea-Università Cattolica del Sacro Cuore - diretta da R. Pieri, Franco Angeli Edizioni.
Rama, D., 2014. Il Mercato Della Carne Bovina. Rapporto 2013. In: Studi di economia agro-alimentare, Franco Angeli.
Sarzeaud, P., Dimitriadou, A., Zjalic, M., 2008. EU Beef Farming Systems and CAP Regulations, no. 9. Wageningen Academic Pub.
Schilling, M.A., Phelps, C.C., 2007. Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. Manage. Sci. 53 (7), 1113–1126.
Tintelnot, F., Kikkawa, K., Mogstad, M., Dhyne, E., 2017. Trade and domestic production networks. University of Chicago, Unpublished Manuscript.
Uzzi, B., 1996. The sources and consequences of embeddedness for the economic performance of organizations: The network effect. Am. Sociol. Rev. 674–698.
Uzzi, B., 1997. Social structure and competition in interfirm networks: The paradox of embeddedness. Adm. Sci. Q. 35–67.
Uzzi, B., Spiro, J., 2005. Collaboration and creativity: The small world problem. Am. J. Sociol. 111 (2), 447–504.
Van Beveren, I., 2012. Total factor productivity estimation: A practical review. J. Econ. Surv. 26 (1), 98–128.