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社会网络与商业信用：基于“结构洞”位置的证据*

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摘要

企业拥有的社会网络能带来竞争优势，而商业信用是企业经营活动竞争力的体现，遗憾的是现有社会网络和商业信用的交叉研究尚缺，本文则研究了企业所处不同结构洞网络位置对其商业信用获取和使用的影响。通过董事的关联关系定义企业社会网络，运用社会网络分析软件计算结构洞网络位置，实证结果发现，企业所处的网络结构洞越丰富，能够获取的商业信用就越多，从而增强了其在产品市场的竞争优势，同时结构洞越丰富的企业“商业信用-现金持有”敏感性越低，即企业结构洞位置能够降低商业信用的使用成本，这一结果在控制了各种内生性和同时考虑网络中心程度的影响后依然存在；进一步研究发现，结构洞位置对商业信用获取和使用成本的影响在竞争更为激烈的行业以及市场发展更充分的地区更加显著，说明结构洞作用的发挥依赖于其形成的市场化因素。此外还发现结构洞网络位置对商业信用的影响更多地存在于信息环境较差、规模较大、上市年龄较久的公司中，且更多地体现在货币政策宽松时期。结果表明结构洞网络位置带来的控制优势和信息优势对企业获取商业信用进而取得竞争优势至关重要。结论为社会网络和公司财务领域提供了证据，对我国企业财务实践活动也有一定的启示。

关键词：结构洞、社会网络、董事网络、商业信用、产品市场竞争
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一、引言

企业的经济行为嵌入社会网络（Granovetter, 1985），其经营活动置身于一定的竞争场域（competitive arena），所以在市场竞争中企业获得的竞争优势不仅是资源优势，而更重要的是关系优势，这种关系优势能带来信任的产生、社会资源的获取和交易成本的降低（Burt, 1992）。所以企业所处社会网络的结构位置差异对其经营的竞争力有直接影响，已有研究发现中国的企业家们积极地拓展自己在外部环境中的结构洞位置以获取有利的资源（Yang, 2004）。而商业信用是企业在产品市场竞争中获取竞争优势的一个重要体现，成为检验企业获得的网络优势能否转化为经营效率的极佳“土壤”。商业信用作为基于信任关系达成的债务契约，会因交易双方的网络结构位置差别而导致谈判能力的区别。在社会网络中一个重要的因素便是网络结构的嵌入性，Burt（1992）首次提出了“结构洞”概念，认为在社会网络中某些个体之间存在无直接联系或关系间断的现象，从网络整体来看，好像网络结构中出现了洞穴。在结构洞存在的情况下将无直接联系的两者联结起来的第三者拥有信息优势和控制优势，从而对企业在市场中的竞争行为具有重要作用。但遗憾的是从社会网络特别是结构洞视角与商业信用的交叉研究一直被学者忽略，本文则试图对此展开探讨。

由于社会网络中的组织悬浮于由各种关系网络组成的环境中，其资源获取的渠道主要来自于所嵌入个人的具体网络，所以依据社会网中“社会交互作用的度量可基于具体的行为人为基础进行建模”的论述（Jackson, 2008），本文通过对企业决策具有重要影响的董事/高管的个体共同任职关系构建网络，基于此研究企业结构洞网络位置与商业信用的关系。具体地，本文利用 2001 至 2011 年 A 股上市公司数据构建了企业通过董事之间共同任职关系产生的董事网络，通过网络约束系数计算了不同企业的结构洞网络位置，进而研究了处于不同结构洞网络位置的上市公司获取商业信用以及使用商业信用成本的差别，实证结果发现，企业在所处的网络结构洞越丰富，能够获取的商业信用就越多，从而增强了其在产品市场的竞争优势；同时结构洞越丰富的企业“商业信用-现金持有”敏感性越低，即商业信用的使用成本越低；进一步研究发现，结构洞位置对商业信用获取和使用成本的影响在竞争更为激烈的行业以及市场发展更充分的地区更加显著，这说明商业信用作为一种基于市场的契约，企业网络位置对其的作用在市场化因素下更强。此外，还发现结构洞网络位置对商业信用的影响更多地存在于信息环境较差、规模较大、上市年龄较久的公司中，且更多地存在于货币政策宽松时期。

论文可能的创新如下：首先，以往研究商业信用的文献基本上基于单个企业自身的属性特征角度，本文则从企业所处社会网络这种企业间的视角，从社会学的结构洞网络位置出发进行研究，不但发现结构洞网络位置能增强商业信用的获取和降低其使用成本，还发现结构洞作用的发挥依赖于市场化的契约因素，从而有效拓展了现有商业信用文献；其次，社会网络和公司财务的交叉研究是国际领域近几年的热点（Engelberg *et al.*, 2012; Cai and Sevilir, 2012; Fracassi and Tate, 2012; Larcker *et al.*, 2013），但已有研究多数基于网络关系视角（如是否具有某种网络关系）来研究，而现

有基于组织和战略等领域的网络结构文献大都基于某一个较小的样本，容易产生对企业所处的网络位置的“人为割裂”（陈运森，2015）。本文则较早地从网络的“结构嵌入性”视角切入，[2] 用我国上市公司的大样本数据进行研究，并发现了企业所处结构洞位置的区别对其公司财务行为具有显著影响；此外，结论还具有现实意义，在近几年资本市场和宏观经济的低迷时期，商业信用无论是作为替代性的融资方式还是市场竞争的手段，对企业的经营都至关重要，本文的结论意味着企业可以通过扩展自身在社会网络中的战略位置来获取商业信用优势，从而能在市场竞争中获得先机。

本文的后续安排如下：第二节是文献综述和研究假说，第三节是研究设计，实证分析在第四节，第五节对全文进行了总结。

二、 文献综述和研究假说的提出

（一）社会网络与商业信用文献综述

社会网络包含网络结构位置和网络关系强度两种视角。首先，从网络结构视角研究企业的文献主要集中于创新创业、战略和组织领域，已有研究发现企业在组织间网络中和管理层网络中的位置影响了企业的战略和绩效（Walker *et al.*, 1997）、创新与创业（Rodan, 2010）、市场份额（Baum *et al.*, 2005; Shipilov *et al.*, 2006）、专利数量（Ahuja, 2000）、知识转移（Reagans and McEvily, 2003）等。Yang（2004）则指出在转型经济国家特别是中国，企业家积极地拓展自己在外部环境中的结构洞位置以获取有利的资源。姚小涛和席酉民（2008）发现高层管理人员的咨询网络中结构洞越多，企业应对行业正常变动的优势越明显。钱锡红等（2010）发现位于网络中心并占有丰富结构洞的企业在创新方面将更具优势。刘冰等（2011）采用中心度指标和结构洞指标对企业的网络位置进行测量，发现不同类型的冗余资源均与企业多元化程度显著正相关，而网络位置所发挥的调节作用却因冗余资源的类型而有所区别。上述文献大都基于某一个较小的样本，这容易产生对企业所处网络位置的“人为割裂”问题。其次，从网络关系强度角度的研究正在成为公司财务的热点，[3] 如：Fracassi and Tate（2012）定义了公司董事和 CEO 在公司外的网络联系，并发现权力越大的 CEO 越可能任命与自己

[2] 从社会学角度来看，社会网络同时包含了决策主体互动的网络关系和网络结构两部分（Granovetter, 1992）。网络关系视角没有特别区分关系的产生是强联结关系还是弱联结关系，只是关注关系的有无和数量，但网络结构视角特别是结构洞位置把关系的类型进行了区分，更多地强调某个个体居于不同性质组织中的“桥梁连接”地位而获取的信息优势（两个组织的信息并不雷同，是差异化的信息）和控制优势（中介位置所产生的不同个体如果需联系必须经过处于中介位置的个体）。企业由董事联结而带来的网络结构嵌入性，注重的是个体在网络中的战略结构位置，强调的是“中介”和“桥梁”的作用。特别是“结构洞”这一在社会网络研究中非常频繁的网络结构位置类型。著名社会学教授 Granovetter（2005）也认为在很多情况下在竞争中最重要的不是某一类型的网络关系“质量”，而是出于不同网络中的“桥”的位置。Zaheer and Bell（2005）就发现公司网络对业绩的影响是通过结构洞网络结构而非直接网络关系来产生的。

[3] 详细的文献综述请参考：陈运森、谢德仁、黄亮华（2012），“董事的网络关系与公司治理研究述评”，《南方经济》，第 12 期：84-93。

有网络联系的董事。Engelberg *et al.*（2012）发现如果银行高管跟公司高管有校友关系，那么企业获得的银行利率更低，未来业绩也更好，从而认为社会网络关系带来了更多的信息或更好的监督。Larcker *et al.*（2013）发现拥有更处于中心位置的董事会能赚取更高的股票回报。陈运森和谢德仁（2011，2012）则用中国资本市场数据验证了居于网络中心位置的独立董事能提高公司的投资效率和高管激励。然而，上述文献诸如Fracassi and Tate（2012）、Engelberg *et al.*（2012）、Larcker *et al.*（2013）等更多地是偏重于对网络关系的存在性和强度的探讨（即是否存在网络关系，或者用网络中心度衡量的网络关系强度如何。国内的一些文献也基本如此，例如：陈运森和谢德仁（2011），而对网络结构的研究不足，也尚未有研究深入探讨企业结构洞网络位置对公司财务行为特别是商业信用的影响。然而，尽管从网络位置视角研究会计、公司财务和治理方面的文献较少，但作为社会网络的一个重要组成部分，这一分支显然不可忽视，Granovetter（2005）和 Jackson（2008）就强调了网络结构位置对包括公司财务机制在内的企业经济后果的重要作用。Mitchell（2005）就发现了在公司组织内部 CEO 所占据的结构洞位置对公司治理效率具有重要影响，同时他也强调公司成员的结构洞位置是公司治理研究中的一个被忽略的因素（missing link in corporate governance），Shaw *et al.*（2005）则选择了结构洞位置作为企业员工网络结构的一种来探讨员工离职、社会资本的散失与企业业绩的影响。Zaheer and Bell（2005）还发现公司网络对业绩的影响是通过结构洞网络结构而非直接网络关系产生的。与本文研究一脉相承的是陈运森（2015），发现企业在所处的网络结构洞越丰富，企业的经营效率和投资效率越高。本文则尝试从企业结构洞位置与商业信用关系的视角来研究社会网络对公司财务行为的影响。

现有的商业信用研究集中于对替代性融资和买方市场理论的探讨，替代性融资理论认为企业提供和获取商业信用是对银行贷款的一种融资替代，而买方市场理论（Fabbri and Menichini, 2010）则认为商业信用大量而普遍地存在主要是与买方（客户）强势、客户信用良好有关，供应商为了促使其产品尽快地销售，愿意为这些客户提供商业信用。余明桂和潘红波（2010）验证了在中国资本市场的商业信用竞争假说，同时发现私有企业比国有企业更多地以商业信用作为产品市场竞争手段。刘凤委等（2009）发现地区间信任差异将导致企业的签约形式显著不同，商业信用模式存在较大差异。陆正飞和杨德明（2011）发现在货币政策宽松期商业信用的大量存在符合买方市场理论，而在货币政策从紧时期替代性融资理论则可以解释我国资本市场商业信用大量存在的原因。刘仁伍和盛文军（2011）发现在现行银行信贷体系下，非国有企业仍存在一定程度的信贷歧视，而商业信贷机制对于银行信贷体系具有显著的补充作用。Wu *et al.*（2012）则指出了应付账款和应收账款的不对称使用成本，并发现金融发展对商业信用使用成本有重要影响。综合来看，从企业间的网络视角研究商业信用获取和使用成本的文献尚缺，本文则从上市公司的大样本数据出发，试图同时结合这两者进行研究。

（二）结构洞网络位置与商业信用的获取

社会学家波特在 1992 年的《结构洞：竞争的社会结构》定义了结构洞：他认为组织和个人的社会网络可以区分成两种类型：一是无洞的结构网络，也就是网络中任何个体与所有其他个体都有直接的联结关系，网络中任何两个个体之间都不存在关系间断的现象；二是有洞的结构网络，即网络中的某些个体与其他部分个体之间没有直接的联结关系，则在某些个体之间就出现了关系间断的现象，从网络整体来看，就好像网络结构中出现了洞穴，这就是 “结构洞”。与无洞的密集网络相比，在充满结构洞的稀疏网络中，处于中心位置的行动者更有优势，原因在于关系稠密的网络中有大量的冗余信息，每个行动者所能获取的信息都比较类似，而在关系较为稀疏的网络中，居于结构洞位置的行动者能够得到丰富的异质性信息，有利于该个体通过差异化的信息获取主导地位以及先行优势。同时，结构洞给行动者带来的不仅有资源获取优势，还有战略位置优势。Burt（1992）认为联结关系的强弱之分与社会资本的多寡没有必然的联系，获取竞争优势的关键是占据交换资源的重要结构位置，具体包括信息优势（information benefits）和控制优势（control benefits）。[4]

我用结构洞理论来解释企业所处社会网络的战略位置差异，用如图 1 表示五个企业作为一个网络的关联图，实线说明两企业间有董事进行兼任，具有直接的联结关系，而虚线则没有。在该网络中有五个参与者 A、B、C、D、E，其中 B、C、D、E 之间没有之间直接联系，但他们分别与 A 有直接联系，那么 A 在网络中处于核心的战略位置，另外四个企业进行交流必须经过企业 A，因此 A 控制了其它企业两两联结的路径。可见，结构洞是非冗余联系人之间的缺口，由于结构洞的存在，洞两边的联系人可以带来累加而非重叠的网络收益，而处于结构洞中心位置的企业则起了关键作用。结构洞理论描绘了一个竞争场域中的社会结构如何为某些行动者创造机会，并由此影响他们之间的关系（Burt, 1992），在竞争市场中拥有丰富结构洞就能获取竞争优势。在衡量企业的结构洞网络位置之前，我把企业与企业的直接联结关系定义为：企业的董事/高管如果在不同企业互相任职，则认为两企业拥有直接的联结关系。[5] 在以董事的关联关系为联结的企业网络中，每个企业董事会的董事都可以看成一个小团体（clique），每个企业的非兼任董事与其它企业的董事之间就没有直接的联系，而是通过连锁董事的关系间接地交流，这样整个企业网络就充满了每个企业董事小网络性质的结构洞。在此情况下结构洞网络位置则是基于董事联结所形成的企业社会网络。[6] 这种对个体层面网络输入，然后组织层面网络输出性的定义是现有社会网络研究的通常做法（如 Jackson, 2008; Larcker *et al.*, 2013）。

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[4] 信息优势是指位于结构洞位置的行动者能够获得及交换来自多方面的异质信息，成为信息的中介。控制优势则指的是位于结构洞位置的行动者能够将没有联结的其他个体联系起来，占据网络中其他节点相互联系的核心路径，从而可以获取对各种关键资源的流向和资源收益的支配权利。

[5] 刘冰等（2011）通过连锁董事构建企业结构洞位置，并与多元化战略相联系。谢德仁和陈运森（2012）通过董事共同任职关系构建了董事网络。

[6] 我计算的是董事的兼任行为产生的网络，在中国上市公司一般来说总经理/CEO 都在董事会中，所以董事网络中也包含了高级管理层的决策。

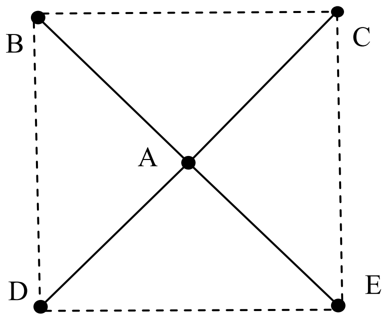

图 1　企业结构洞示意图

从社会网络视角来看，结构洞是社会结构中原来没有联系的网络成员之间建立间接的关系以获取信息和控制优势，并基于此来定义社会资本，认为在网络成员之间是否有结构洞就决定了信息与机会的潜力。在具有丰富结构洞位置的企业网络中，起到中介作用的就是“桥”，作为桥的节点能够连接分离的企业子网络，起到信息沟通和交流的作用。企业处于“桥”位置的节点，就占据了掌握信息流和商业机会的位置，更容易获得中介利益。这种中介利益体现在控制优势和信息优势中。下面具体结合商业信用的获取和使用行为进行说明。

商业信用是在一定技术水平约束和相应市场竞争环境中企业间彼此达成经营共识的基础上完成的市场化资源配置过程，是一种无抵押的债务契约关系，它的使用导致交易过程中商品与现金的交换在时间上相分离，当期的收入（支出）变成企业未来的现金流入（流出）。企业在产品市场竞争中如果能获得更多的商业信用，就意味着该企业占用了其它企业的现金而获得了无息的“短期融资”，同时也是一种产品市场竞争力的有力体现。而社会网络基于市场中交易各方竞争的博弈，能够反映交易双方的相对谈判地位，以至于在经济社会学领域通过博弈论及其相关理论对社会网络进行度量（Jackson, 2008）。所以从本质上说，商业信用契约关系反映的是不同企业的战略谈判位置的区别，如果某个企业在社会网络中位于结构洞的中心位置，意味着相对于同行业的其它公司，它能够更多地获得产品市场竞争中的控制优势和信息优势，这种优势带来的谈判主动地位可以使企业在交易过程中更好争取有利于自己的商业信用模式。具体来说：第一，商业信用双方的信息对称是这种契约关系产生的关键，从企业面临的整体网络来看，如果某企业处于结构洞中心位置，意味着它（通过董事的沟通交流）占据了网络中不同企业沟通路径的关键，可以获取有关于商业信用合约相关的信息优势，这种信息优势即可以让其它企业更容易与之达成商业信用关系，从而可以建立起低成本的商业信用关系；第二，买方市场理论认为商业信用之所以大量存在，主要是与买方强势、客户信用良好有关，这种强势体现在控制优势和议价能力（bargaining power）中，结构洞网络位置能够为企业带来对供应链中其它企业的控制优势，而商业信用的产生源于交易谈判时的控制力，如果这种结构洞位置带来的战略控制优势越明显，在与供应商的交易过程中议价能力就越能够得到体现，自然能够获取的商业信用

也就越多。第三，商业信用体现的是一种隐性的信任（陈运森和王玉涛，2010），作为没有任何实物担保的商业信用契约，声誉是其合约达成的重要因素，而企业的战略位置能够使企业自身获取这种信任和声誉（陈运森和谢德仁，2011），越处于社会网络的结构洞位置，就越能够获得网络中其它企业的信任以及非正式的影响力。所以综合来看，企业结构洞网络位置带来的信息优势、控制优势和信任优势能够使之获得更多商业信用。

由于本文所研究之企业网络为基于董事直接和间接兼任关系而产生的网络，一般来说，每个企业在不同程度上都同时扮演了供应商、生产者和客户三种角色，实证研究中也较难区分其具体类型，而且不同的董事任职情况也很难确定是否是同一产业链条的供应商、生产者和客户，所以本文主要以生产者的视角来检验从供应商处获得的商业信用，且从较为广泛意义的董事网络而非具体的某一产业链条网络的逻辑视角来研究结构洞位置的增量作用。结合前述结构洞网络带来的信息优势、控制优势和信任优势，退一步讲，即使董事的网络关系并没能直接“打通”企业的“供应商-客户”链条（董事网络带来的并非直接的“供应商-客户”关联关系），这也不影响董事网络中结构洞位置对商业信用的作用发挥。原因如下：首先，网络位置的“符号效应”[7] 会让企业的供应商形成这样一种观点：在其它类型网络中掌握信息优势和控制优势的客户企业的经营和财务风险要更低，而且这种董事网络带来的是公司层面总体的信息环境和产品竞争力体现，能够对本企业（供应商角色）提供的商业信用有保障作用；其次，由于在公司融资中具有网络传递（network transitivity）效果（Uzzi and Gillespie, 2002），网络的动态性使得一种类型交易伙伴的网络能够增加其与另一类交易伙伴的交易，而能降低对与第三方交易形成独特的排他性资源伙伴的需求。这种网络传递效果在本文逻辑中也存在，也许董事网络带来的并非直接的“供应商-客户”网络，但其它类型的网络所带来的各种交易成本降低能够传递到“供应商-客户”网络关系中，能够增加供应商对客户提供的商业信用。Uzzi and Gillespie（2002）就发现公司和银行的嵌入网络能够形成独特的治理机制进而鼓励和保护银行的能力，这些可以进一步促进公司跟商业信用供应商的交易；再次，从反面来讲，由于客户的结构洞位置能够带来各类资源，万一这种类型的企业在商业信用合约中违约而率先破坏稳定的信用关系，这种声誉的受损会通过其核心的结构位置传染到不同的合约相关方，会让其损失除了商业信用之外的其它各类社会资本，从而对企业自身的影响巨大，所以这种网络传染效应让处于结构洞位置的企业不得不遵守商业信用的合约，即这种企业所处核心结构洞位置而带来的正面和反面影响都能够给企业带来更多的商业信用获取。

[7] Lin（2002）认为社会网络带来的声望具有符号效用。行动者即使不能使用或动员镶嵌于社会网络中的这些资源，它们也有很大的“符号感”，即让别人知道自己的社会资本，可以很好地改善自己的地位和社会声望。Kilduff and Krackhardt（1994）也发现如果个体被认为在组织中拥有一位声名显赫的朋友，会提升该个体作为好的工作执行者的声望，尽管实际上拥有这样的朋友可能并没有这样的效果，这就是认知平衡理论（Cognitive Balance Theory）的体现。

基于此，我提出本文的第一个研究假说：[8]

H1a：企业所处的董事网络中结构洞越多，企业所能获得的商业信用就越多。

（三）结构洞网络位置与商业信用的使用成本

在市场中企业获取商业信用是一种竞争地位的体现，获取商业信用越多，就意味着在短期内占用供应商的资金越多。但是，在企业获取商业信用的同时需要为之提供一定的预期性现金以备将来的信用偿还责任，原因在于：延期的商业信用偿还是有成本的，比如未来可能的现金折扣减少、受到延期支付惩罚、对信用声誉损害（信用评级降低）伴随的机会成本，以及未来供应商增加的产品卖出价格。为了避免可能的延期支付成本和现金折扣减少，将要持有部分储备性现金。实际上，在现实资本市场中存在各种“摩擦”、行业调整、宏观政策变更以及客户自身经营状况等诸多会导致客户未来的现金返还预期产生不确定的因素，这些因素的不确定都会影响到未来的现金流出（还款），根据现金持有的动机理论，出于风险预防和交易成本的考虑企业需额外持有多余现金（Lins *et al.*, 2010）。此外，有的企业为了享受一定的现金折扣，也会持有一定的现金以在截止日之前进行信用支付。我把因使用商业信用而导致的现金持有增加的行为称作商业信用的使用成本，企业对商业信用的使用会对企业自身流动性产生压力，从而导致“商业信用-现金敏感性”提高（Wu *et al.*, 2012）。

类似于上述“结构洞位置与商业信用获取”逻辑，企业所处的结构洞网络位置产生的信息优势和控制优势能使企业获得交易各方的信任，降低交易的不确定性，不仅可以获取更多商业信用，也可以有效降低商业信用使用的成本。具体地，首先，商业信用的成本风险源于其本质是基于信任关系所达成的债务契约，契约的签订不仅会产生直接的交易成本，还可能伴随违约的风险成本（Williamson, 1998; Fabbri and Menichini, 2010）。而从商业信用获取和使用的视角，由于商业信用的获取需要付出流动性成本，这种商业信用成本从本质上说是一种信息不对称和不确定的体现，企业的战略核心位置让其能够降低由信息不确定产生的商业信用使用成本。商业信用的使用成本体现的是在交易过程中的交易成本，供应商和客户之间的交易网络决定了市场对企业的约束，基于各种嵌入在公司权威下受约束的交易背景，企业的网络结构关系使得交易更加方便，否则这些交易的可谈判性会受到约束。从而在网络中处于结构洞优势地位的企业，就能够利用在网络中的控制力来降低交易费用。其次，结构洞位置丰富的公司还可以通过降低自身的流动性风险来保证商业信用的使用。如果结构洞位置越丰富，意味着企业可以获得更多的外部融资，或者即使现阶段不用获得这种融资，

[8] 需指出的是，社会资本的获取可以通过闭合网络（Network Closure）和结构洞位置（Structural position）两种网络机制来获取，Coleman（1990）认为在一个闭合网络中强联结关系能带来规范和信任。如果是此逻辑占主导，则跟本文假说相反，但是我想强调的是，闭合网络逻辑的产生需要依赖于网络中紧密相连的强联结网络关系特征，属于群体内社会资本的来源，而上市公司之间以及上下游之间是群体外的特征，更多地属于松散的非正式的非闭合性网络，公司与公司之间并非紧密相连的强联结关系，所以在此背景下基于弱连接关系的结构洞逻辑更多地运用在本文逻辑中。尽管如此，需指出的是，本文逻辑中更多的体现是结构洞位置，但可能依然存在网络闭合的逻辑，需要实证结果的检验。

但其潜在的“资金蓄水池”让其能够降低对现金的持有，居于结构洞核心位置的企业可以降低企业未来的流动性预期，进而就不用更多的持有现金。基于此提出第二个假说：

H1b：企业所处的董事网络中结构洞越多，企业的“商业信用-现金持有”敏感性越低。

（四）结构洞网络位置与商业信用获取及使用成本：基于市场的权变因素

Podolny and Baron（1997）提出了结构洞的权变观点，认为结构洞位置是否能转化为社会资本要依赖于具体的网络内容即参与者之间关系的性质。本文所定义的企业间网络与商业信用行为在实质上都属于一种交易网络，体现的是企业之间的交易性质如何影响他们在市场上行动的认识（Jackson, 2008），所以如果交易的平台越市场化，则结构洞网络位置发挥的作用越强。商业信用的使用及其所需承担的流动性成本与市场有很大的关系，由于市场化色彩的配置过程会使厂商和客户之间自然地形成一个契约关系（Peterson and Rajan, 1997），从而能够同时为企业战略位置和商业信用的使用提供“土壤”，这种市场因素的体现可以从市场中的行业竞争程度和地区市场深化水平来分析。

首先，结构洞作用的发挥依赖于企业所处的行业竞争程度。第一，在垄断性行业中，企业可以利用自身的垄断地位获得产业链中的优势地位，进而获取商业信用。此时，对于处于垄断地位的行业而言，企业基于董事的网络类型就属于低自主性网络，即通过董事个体所处网络获得信息和控制优势对企业行为的影响降低，从而更少地依赖于通过董事兼任而形成的网络的作用发挥（也即：企业通过自身垄断地位就可以轻易获得商业信用，从而结构洞位置的作用就不明显）；但是，在竞争激烈的行业中，由于不同企业都不能通过自身的固有垄断地位来取得显著优于其它企业的回报，那么基于董事网络的结构洞位置就更能给企业带来涉及商业契约的信息和控制利益，即在此背景下董事网络的结构自主性更强（Structural Autonomy），自然地企业更可以通过个体掌握的社会网络来获得其更具竞争性的优势位置，从而结构洞位置的作用更加体现。第二，商业信用的竞争假说认为商业信用可以作为竞争市场中的一种竞争手段，当供应商面对的同行业竞争者较多时，企业能够很容易找到替代性的供应商，从而使得企业商业信用的获取在竞争激烈的行业中更加敏感。同时，由于行业竞争激烈，企业在获得商业信用之后也更增加了自身的流动性风险，张会丽和吴有红（2012）就发现产品市场竞争和超额现金持有具有关联关系，而此时社会网络的结构位置优势在竞争的市场中便更能得到体现，在产品市场竞争高的行业，结构洞关键位置使得企业能够获得更多的商业信用，同时也会使“商业信用-现金持有”策略更加敏感。

其次，结构洞网络的形成是企业在市场中的自发行为，而商业信用政策也是市场交易的结果。如果企业所处地区的市场深化和发育程度越好，那么结构洞网络位置对商业信用的影响也越大。Coleman（1990）就认为网络关系中的规范与惩罚制度的建立要基于这种合约是否发生于一个可信赖的环境之中。当企业所在地区的市场深化水平

更高的时候，企业与利益相关者签订和执行各种合约具有良好的公共履约环境（陈运森和王玉涛，2010），在这种背景下基于市场交易网络的商业信用行为也更加市场化，从而更有利于结构洞网络位置的作用发挥。基于此提出另两个假说：

H2a：**在产品市场竞争越强的行业，结构洞网络位置对商业信用获取及使用成本的影响越大。**

H2b：**在市场化水平越高的地区，结构洞网络位置对商业信用获取及使用成本的影响越大。**

三、 研究设计

（一）研究模型和变量定义

为研究结构洞位置与商业信用的关系，本文同时考虑商业信用的获取和使用成本，构建模型如下：

$$TC_{it} = \alpha_0 + \alpha_1 CI_{it} + \sum Controls_{it-1} + \varepsilon \quad (1)$$

$$CASH_{it} = \beta_0 + \beta_1 CI_{it} + \beta_2 CI_{it} \times TC_{it} + \beta_3 TC_{it} + \sum Controls_{it-1} + \delta \quad (2)$$

其中，模型（1）用来检验结构洞网络位置与商业信用获取的关系，模型（2）用来检验结构洞位置对商业信用的使用成本的影响（Wu *et al.*, 2012）。借鉴 Burt（1992）、Zaheer and Bell（2005）和陈运森（2015），我用如下模型进行结构洞的计算：

$$C_{ij} = (p_{ij} + \sum_q p_{iq} p_{jq})^2 \quad (3)$$

其中，i 为整体上市公司网络中的某个企业个体，j 表示网络中的其它企业，q 表示另一个企业个体，即：$q \neq i, j$。P_{ij} 等于企业 i 到企业 j 的直接连带关系的强度（如果某董事同时在 i 和 j 任职，那么就认为这两个公司有直接连带关系），衡量的是企业 i 在 j 中的直接关系投资，而 $\sum_q p_{iq} p_{jq}$ 等于从 i 到 j 的所有通过 q 的路径中，非直接连带关系的强度之和，衡量的是企业 i 在企业 j 身上的间接关系投资，而 C_{ij} 是企业 i 与企业 j 接触联系所需关系投资的约束程度，即“约束指数”，这能够有效地测量企业结构洞的匮乏程度。因为“约束指数”的最大值为 1，为方便起见，学者们常用 1 与“约束指数”的差来衡量结构洞丰富程度（Burt, 1992; Zaheer and Bell, 2005）：$CI_i = 1 - C_{ij}$，如果 CI_i 越大，就表明网络约束越小，网络结构洞越丰富。所以本文也通过 CI 指标来衡量企业的结构洞丰富程度。[9]

本文使用了四类商业信用指标（TC）：$TC1$ 为第 t 年末（应付账款＋应付票据）/

[9] 附录中详细介绍了结构洞指标的计算方法。

总资产，考虑到企业在获取商业信用的同时也在提供商业信用，所以 *TC2* 考虑了商业信用获取净值，为第 *t* 年末（应付账款＋应付票据－应收账款－应收票据）/总资产，同时商业信用的提供涉及到行业差异，所以也用行业调整后的 *TC1_adj* 和 *TC2_adj* 来进行衡量，且在分样本研究中主要以综合的 *TC2_adj* 为研究变量。借鉴 Wu *et al.*（2012），*CASH* 定义为：第 *t* 年末货币资金/（总资产－货币资金）。预测模型（1）中 α_1 为正，即企业结构洞网络位置越强，能够获取的商业信用越多，预测模型（2）中的交叉项 β_2 为负，即结构洞网络位置越强，“商业信用-现金持有”的正相关关系越弱。借鉴现金持有的相关文献（Lins *et al.*, 2010; Wu *et al.*, 2012），控制了公司规模、杠杆水平、成长性、投资、经营现金流、最终控制人等主要的公司治理变量以及公司基本状况变量，同时也设置 *POST* 变量控制 2007 年《物权法》实施对商业信用融资的影响（Wu *et al.*, 2012）。2007 年《物权法》及按其要求制定的《应收账款质押登记办法》使得银行可为企业商业信用合约抵押提供更加丰富和有针对性的应收账款金融产品，降低企业对应收账款回收的技术难度，减少了企业未来现金流的不确定性，从而影响了企业的商业信用行为。当然 2007 年上市公司实行了新准则，而且股权分置改革基本完成，所以 *POST* 变量也控制了这些方面的可能影响。为了降低机械性相关，我对控制变量进行了滞后一期处理，详细的变量定义参见表 1。在回归分析中，区分行业竞争程度（*HHI*）和市场化程度（*MKT*），进而分析结构洞网络位置与商业信用获取及使用成本的关系在市场化权变因素中的差别作用。

表 1　变量定义表

变量名称	符号	变量定义
网络约束系数	*CI*	“结构洞”衡量指标，方法见前述，通过 Pajek 软件计算。
	TC1	第 *t* 年末（应付账款+应付票据）/总资产。
	TC1_adj	经行业中位数调整后的第 *t* 年末（应付账款＋应付票据）/总资产。
商业信用	*TC2*	第 *t* 年末（应付账款＋应付票据－应收账款－应收票据）/总资产。
	TC2_adj	经行业中位数调整后的第 *t* 年末（应付账款＋应付票据－应收账款－应收票据）/总资产。
现金	*CASH*	第 *t* 年末货币资金/（总资产－货币资金）。
公司规模	*SIZE*	第 *t*−1 年末总资产的自然对数。
杠杆水平	*LEV*	第 *t*−1 年末总负债/总资产。
成长性	*MB*	第 *t*−1 年市场价值/账面价值。
投资	*INV*	第 *t*−1 年（固定资产＋在建工程＋无形资产＋长期投资）/总资产。[10]
经营现金流	*OCF*	第 *t*−1 年经营现金净流量/总资产。
最终控制人	*SOE*	哑变量，如果企业最终控制人为国有则取 1，否则为 0。
物权法前后哑变量	*POST*	哑变量，如果年份在 2007 年及之后则取 1，否则为 0。
行业竞争程度	*HHI*	赫芬达尔指数哑变量，如果高于所有行业中值则为 1，否则为 0。
市场化程度	*MKT*	哑变量，如果市场化指数高于同年度中值则为 1，否则为 0。
行业/年份	*IND/ YEAR*	行业参照 2001 年证监会行业分类标准，制造业为二级行业分类标准，其他为一级行业分类标准。样本区间为 11 年，故设 10 个年度哑变量。

[10] 2006 年新准则之后长期投资＝持有至到期投资＋可供出售金融资产＋长期股权投资净额。

（二）样本和数据

我选取了 2001 至 2011 年共 11 年的样本区间，在剔除金融行业公司样本、公司董事资料缺失样本以及其他财务和公司治理数据缺失的样本后，共获得 12,167 个公司-年份观测值(不同变量缺失值不同，在不同的模型中进入回归模型的样本量有所不同)。在计算企业所处结构洞位置时，由于是基于董事的网络联结关系，首先对于每个公司每一年的样本搜集董事会的所有董事作为基础信息；其次对每一个董事赋予独一无二的代码；在整理出干净和独特的上市公司董事数据库后，构建“董事−董事”一模矩阵，矩阵勾勒出了不同董事之间的联结关系，如果董事 i 和 j 在至少同一个公司任职，那么矩阵（i, j）的值为 1，否则为 0。在这些处理之后用大型社会网络分析软件 Pajek 计算结构洞位置的“网络约束指数”指标。为消除极端值影响，对主要连续变量上下 1%进行了 Winsorize 处理；同时对公司层面做了聚类（Cluster）调整；统计和回归分析用 SAS 软件。

四、 检验结果

（一）描述性统计[11]

变量描述性统计如表 2 所示：网络约束系数的均值为 0.273（中位数为 0.047），最大值和最小值相差 0.896，表明不同公司的结构洞丰富程度差异较大，这方便了我对此进行的研究。商业信用获取（*TC1*）的均值为 0.118，说明应付账款和应付票据占到了总资产的近 12%，商业信用的使用成为上市公司产品市场竞争的重要手段。*CASH* 平均达到了 0.21，这反映了上市公司的现金持有占总资产比重也较大，如何有效管理现金成为企业的一个重要问题。

表 2 描述性统计

变量	N	均值	中位数	最大值	最小值	标准差
CI	12167	0.273	0.047	0.896	0.000	0.298
CASH	12163	0.207	0.142	1.716	0.006	0.227
TC1	12167	0.118	0.091	0.392	0.002	0.096
TC1_adj	12167	0.022	0.001	0.266	-0.111	0.084
TC2	12167	-0.010	-0.004	0.235	-0.360	0.113
TC2_adj	12167	0.003	0.002	0.240	-0.286	0.103
SIZE	12164	21.302	21.204	24.214	19.126	1.075
LEV	12164	0.516	0.511	1.172	0.074	0.218
MB	12096	1.587	1.276	5.049	0.855	0.867
INV	12156	0.451	0.445	0.860	0.033	0.209
OCF	12164	0.049	0.048	0.237	-0.159	0.079
SOE	12140	0.644	1.000	1.000	0.000	0.479
POST	12167	0.379	0.000	1.000	0.000	0.485
HHI	12167	0.257	0.000	1.000	0.000	0.437
MKT	12167	0.728	1.000	1.000	0.000	0.445

[11] 篇幅所限，相关系数分析未提供，留存备索。

图 2 则显示了不同结构洞丰富程度企业的商业信用获取对比情况，如果把企业按照 *CI* 分为高低两组（以中位数为标准，实际上与以平均值为标准的结果类似），发现如果企业拥有丰富的结构洞，则能够获取的商业信用要远远高于稀疏结构洞的企业，这一趋势初步验证了 H1a。

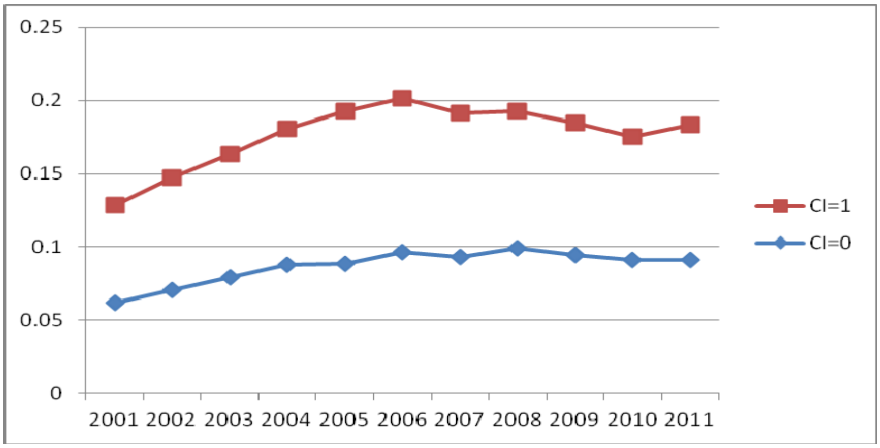

图 2　不同结构洞丰富程度企业的商业信用获取（中位数）趋势图

（二）回归分析

模型（1）和（2）的回归结果在表 3 中，前四列显示的是企业结构洞丰富程度与商业信用获取额的关系，当因变量为 *TC1* 和 *TC1_adj* 时，*CI* 与 *TC* 在 5%水平下显著正相关，若同时考虑商业信用获取和商业信用提供后的净额（*TC2* 和 *TC2_adj*），*CI* 系数接近显著。考虑到 *TC2_adj* 是“经行业中位数调整后的第 *t* 年末（应付账款＋应付票据－应收账款－应收票据）/总资产”，同时考虑了商业信用净额以及行业调整，是本文研究中较为全面的一个指标，所以本文后续使用了 *TC2_adj* 作为细分样本的主要研究指标；5 至 8 列显示的是企业结构洞丰富程度与商业信用使用成本的关系，无论自变量为四个 *TC* 变量的哪一个，*CI* 的系数都显著为负（分别在 5%和 1%水平下显著），而 9 至 12 列则列示了行业调整后的现金持有作为因变量（*CASH_adj*）的结果，[12] 除了自变量为 *TC1_adj* 时的交叉项系数不显著，其它三个交叉项系数都在 5%或 1%水平下显著为负。5 至 12 列的结果说明企业丰富的结构洞位置显著降低了“商业信用-现金”的敏感度。从表 3 的结果来看，总体上 H1a 和 H1b 得到验证。

从市场化动因的权变视角来进一步研究结构洞网络位置与商业信用的关系结果在表 4 和表 5 中，[13] 其中表 4 显示的是区分产品市场竞争程度的结果，前两列为区分 *HHI* 之后的结构洞丰富程度与商业信用获取结果，当 *HHI* = 0 时 *CI* 的系数并不显著，当 *HHI* = 1 时 *CI* 系数显著为正（系数为 0.023，在 1%水平下显著），两者的差异为 0.019，

[12] 感谢审稿人的建议。
[13] 篇幅所限，只显示 *TC* = *TC2_adj* 的结果，但其它变量结果类似，留存备索。

表 3　结构洞网络位置与商业信用回归结果

	1	2	3	4	5	6	7	8	9	10	11	12
	因变量：*TC*				因变量：*CASH*				因变量：*CASH_adj*			
	TC1	*TC1_adj*	*TC2*	*TC2_adj*	*TC1*	*TC1_adj*	*TC2*	*TC2_adj*	*TC1*	*TC1_adj*	*TC2*	*TC2_adj*
TC					0.021	0.014	0.398***	0.406***	-0.021	0.0093	0.39***	0.40***
					(0.39)	(0.25)	(11.59)	(11.72)	(-0.38)	(0.85)	(11.45)	(11.79)
*CI*TC*					-0.216**	-0.258**	-0.187***	-0.187***	-0.20**	-0.013	-0.18***	-0.18***
					(-2.39)	(-2.53)	(-2.81)	(-2.90)	(-2.27)	(-0.23)	(-2.72)	(-2.88)
CI	0.006**	0.006**	0.003	0.003	0.028*	0.008	-0.001	0.001	0.028*	-0.25**	-0.0000012	0.0028
	(2.38)	(2.37)	(1.60)	(1.51)	(1.79)	(0.73)	(-0.14)	(0.14)	(1.81)	(-2.47)	(-0.00)	(0.27)
SIZE	0.005***	0.005***	0.015***	0.015***	-0.006	-0.006	-0.012***	-0.012***	-0.0064	-0.0063	-0.012***	-0.012***
	(5.97)	(6.33)	(7.15)	(7.16)	(-1.56)	(-1.52)	(-2.91)	(-2.93)	(-1.58)	(-1.55)	(-2.93)	(-2.97)
LEV	0.128***	0.125***	0.074***	0.076***	-0.203***	-0.203***	-0.242***	-0.243***	-0.20***	-0.20***	-0.24***	-0.24***
	(37.06)	(36.58)	(7.72)	(8.18)	(-9.17)	(-9.20)	(-11.21)	(-11.27)	(-9.18)	(-9.20)	(-11.22)	(-11.30)
MB	-0.008***	-0.007***	-0.003	-0.003	0.026***	0.026***	0.028***	0.028***	0.025***	0.025***	0.026***	0.026***
	(-6.99)	(-5.98)	(-1.40)	(-1.15)	(4.71)	(4.72)	(4.98)	(4.91)	(4.39)	(4.40)	(4.65)	(4.59)
INV	-0.100***	-0.101***	0.042***	0.042***	-0.412***	-0.413***	-0.418***	-0.418***	-0.41***	-0.41***	-0.41***	-0.41***
	(-24.09)	(-24.51)	(4.06)	(4.10)	(-17.08)	(-17.06)	(-18.23)	(-18.25)	(-16.83)	(-16.82)	(-18.04)	(-18.07)
OCF	0.077***	0.079***	0.152***	0.146***	0.474***	0.475***	0.415***	0.417***	0.46***	0.46***	0.40***	0.40***
	(7.95)	(8.29)	(9.48)	(9.18)	(10.40)	(10.40)	(9.48)	(9.49)	(10.10)	(10.11)	(9.20)	(9.19)
SOE	0.010***	0.010***	0.008*	0.008*	0.019**	0.019**	0.016**	0.015**	0.020**	0.020**	0.016**	0.016**
	(6.37)	(6.34)	(1.88)	(1.88)	(2.43)	(2.42)	(2.09)	(2.08)	(2.54)	(2.53)	(2.21)	(2.19)
POST	0.014***	0.002	0.044***	0.016***	0.058***	0.057***	0.005	0.016	0.023**	0.022**	0.015	0.030***
	(3.92)	(0.61)	(8.51)	(3.16)	(5.80)	(5.74)	(0.51)	(1.47)	(2.17)	(2.05)	(1.59)	(3.08)
CONS	-0.053***	-0.100***	-0.425***	-0.386***	0.551***	0.551***	0.709***	0.699***	0.38***	0.38***	0.54***	0.53***
	(-2.80)	(-5.41)	(-9.16)	(-8.44)	(5.82)	(5.81)	(7.38)	(7.30)	(4.06)	(4.04)	(5.65)	(5.58)
YEAR/IND	√	√	√	√	√	√	√	√	√	√	√	√
R-sqr	0.338	0.160	0.218	0.096	0.224	0.224	0.246	0.246	0.179	0.179	0.203	0.203
F-Value	175.98	65.61	38.18	13.10	20.15	20.22	20.61	20.69	16.14	16.16	18.53	18.88
Obs.	12103	12103	12064	12064	12101	12101	12062	12062	12100	12100	12061	12061

注：括号内为 t 值，*、**、***分别表示在 10%、5%和 1%水平下显著；结果经过公司层面的 Cluster 调整。

邹检验进一步说明两者差异在5%水平上显著，说明当产品市场竞争激烈时，结构洞网络位置对商业信用获取的增加作用更加明显；而后两列为区分 *HHI* 之后的结构洞网络位置与商业信用使用成本的差异结果，当 *HHI* = 0 时 *CI*TC* 的系数为 -0.173，但当 *HHI* = 1 时系数为 -0.255，系数差异 -0.082，邹检验显示 F 值在1%水平下显著，说明当产品市场竞争激烈时，结构洞网络位置对商业信用使用成本的节约作用更加明显。H2a 得到验证。

表 5 显示的为区分地区市场深化之后的结果，与表 4 类似，当因变量为 *TC* 时，*MKT* = 0 时 *CI* 系数不显著，当 *MKT* = 1 时 *CI* 系数在10%水平下显著为正，邹检验发现差异（0.012）在 1%水平下显著，说明在市场化程度更高的地区，结构洞网络位置对商业信用获取程度的作用更强；当因变量为 *CASH* 时，*MKT* = 0 时 *CI*TC* 系数不显著，当 *MKT* = 1 时 *CI*TC* 系数在1%水平下显著为负（系数为 -0.205），邹检验发现差异（-0.149）在1%水平下显著，说明在市场化程度更高的地区，结构洞网络位置对商业信用的使用成本节约作用更大。H2b 得到验证。

表 4　产品市场竞争、结构洞网络位置与商业信用

	因变量：*TC2_adj*			因变量：*CASH*		
	HHI=0	*HHI*=1	Chow-F	*HHI*=0	*HHI*=1	Chow-F
TC				0.394***	0.430***	
				(15.35)	(7.98)	
*CI*TC*				-0.173***	-0.255**	-0.082***
				(-3.04)	(-2.11)	(4.24)
CI	0.004	0.023***	0.019**	-0.005	0.026*	
	(1.07)	(3.80)	(2.59)	(-0.73)	(1.86)	
SIZE	0.019***	0.006***		-0.009***	-0.015***	
	(14.74)	(3.42)		(-3.65)	(-3.57)	
LEV	0.076***	0.071***		-0.223***	-0.285***	
	(14.48)	(9.16)		(-22.33)	(-15.56)	
MB	-0.003**	-0.000		0.029***	0.029***	
	(-2.03)	(-0.00)		(8.93)	(4.51)	
INV	0.051***	0.021**		-0.393***	-0.505***	
	(8.19)	(2.16)		(-33.55)	(-22.01)	
OCF	0.156***	0.113***		0.387***	0.480***	
	(10.86)	(5.00)		(14.17)	(9.07)	
SOE	0.008***	0.003		0.015***	0.014	
	(3.61)	(0.74)		(3.45)	(1.54)	
POST	0.013**	0.017*		-0.002	0.067***	
	(2.39)	(1.91)		(-0.16)	(3.43)	
CONS	-0.470***	-0.194***		0.590***	0.941***	
	(-16.42)	(-4.68)		(10.74)	(9.71)	
YEAR/IND	√	√		√	√	
R-sqr	0.109	0.076		0.221	0.325	
F-Value	39.20	9.00		84.75	49.09	
Obs.	8977	3087		8976	3086	

注：括号内为 t/F 值，*、**、***分别表示在10%、5%和1%水平下显著；结果经过公司层面的 Cluster 调整。

表 5 市场深化、结构洞网络位置与商业信用

	因变量：*TC2_adj*			因变量：*CASH*		
	MKT=0	*MKT*=1	Chow-F	*MKT*=0	*MKT*=1	Chow-F
TC				0.346***	0.411***	
				(6.52)	(9.38)	
*CI*TC*				-0.056	-0.205***	-0.149***
				(-0.52)	(-2.64)	(4.75)
CI	0.010	0.022*	0.012***	0.007	-0.007	
	(0.94)	(1.77)	(4.12)	(0.54)	(-0.54)	
SIZE	0.020***	0.013***		0.000	-0.017***	
	(4.87)	(5.42)		(0.04)	(-3.53)	
LEV	0.059***	0.081***		-0.188***	-0.265***	
	(3.42)	(7.56)		(-6.04)	(-9.80)	
MB	0.005	-0.006**		0.030**	0.028***	
	(1.21)	(-2.00)		(2.26)	(4.67)	
INV	0.056***	0.038***		-0.333***	-0.442***	
	(2.94)	(3.23)		(-9.93)	(-16.09)	
OCF	0.131***	0.147***		0.371***	0.427***	
	(4.24)	(8.10)		(4.80)	(8.12)	
SOE	0.002	0.011**		0.013	0.019**	
	(0.24)	(2.33)		(1.02)	(2.11)	
POST	0.009	0.013***		0.031	0.061***	
	(0.87)	(2.81)		(1.64)	(5.41)	
CONS	-0.482***	-0.346***		0.363*	0.816***	
	(-5.48)	(-6.57)		(1.83)	(7.45)	
YEAR/IND	√	√		√	√	
R-sqr	0.104	0.102		0.220	0.260	
F-Value	6.32	9.82		10.59	15.93	
Obs.	3282	8782		3281	8781	

注：括号内为 t/F 值，*、**、***分别表示在 10%、5%和 1%水平下显著；结果经过公司层面的 Cluster 调整。

（三）稳健性检验

为了结论的稳健，我做了一系列稳健性检验，结果如下：

1、商业信用政策既包括商业信用获取也包括商业信用提供，回归结果同时考虑了商业信用获取及净获取，在稳健性检验中则用“（应收账款＋应收票据）/总资产”（*TC3*）及其行业调整值（*TC3_adj*）来衡量企业主动提供商业信用的代理变量（Wu *et al.*, 2012），发现结构洞网络越丰富的企业，能够主动提供的商业信用也越多，这就更能加强其在产品市场竞争中的优势。*TC3_adj* 的结果见表 6 的第 1 列和第 2 列，篇幅所限，*TC3* 结果未报告，与 *TC3_adj* 结果类似，且与主要检验结果一致；我也做了 *TC1_adj* 的细分样本（区分产品市场竞争程度和地区市场环境）研究，结果发现除了在商业信用获取模型中 *CI* 指标在市场环境好和坏的地区分样本都不显著之外，其它的结果都符合预期；此外，由于商业信用与银行信用在某种程度上是替代的关系，如果

企业结构洞位置越丰富，则通过商业信用占用的资金越多，向银行贷款就越少，基于此我用“（应付账款＋应付票据）/总负债”作为商业信用的替代变量，未报告的结果显示论文基本结论不变。

2、关于可能的内生性问题，我做了如下检验：[14]（1）主要回归结果中对控制变量进行了滞后一期处理，其实如果所有变量都在 *t* 期，结果也一致。表 6 的第 3 和第 4 列显示，当因变量为 *TC2* 时 *CI* 系数不显著，当因变量为当期的 *TC2_adj* 时，*CI* 系数在 10%水平下显著正相关，当因变量为 *CASH* 时 *CI*TC* 系数在 1%水平下显著负相关，支持了 H1a 和 H1b；（2）我也进行了公司层面的固定效应模型检验（用 *TC2_adj* 代替 *TC* 变量），结果如表 6 最后两列所示结果类似；（3）借鉴 Larcker *et al.*（2013）解决内生性的方法，进行了如下处理：首先，为了排除“好公司吸引了具有网络背景的董事，同时也获得了更多商业信用”，进行了董事是否聘任具有网络背景董事的影响因素模型分析，Larcker *et al.*（2013）控制了业绩、杠杆水平、成长性、公司规模等公司层面的基本特征变量，我在此基础上进一步控制了“最终控制人性质、董事会规模、独立董事比率、两职合一”这些公司治理变量，因为我认为，公司的现有董事会特征会影响未来董事的聘任决策。基于上述变量，选取 *t*+1 期 *CI* 为因变量，对结构洞位置的影响因素模型进行了检验，结果见表 7，前一期的商业信用（*TC*）与 *CI* 的系数并不显著，就说明本文的结果并非是“好的公司同时能提供更多商业信用，也能聘任网络程度高的董事”。此外，*ROA* 与 *CI* 的系数显著为负，这说明反而是那些以往业绩不好的所谓的“差公司”更愿意聘任网络程度高的董事；其次，尽管这类研究无法获取严格意义上的外生变量，但可以把分析限制在那些董事会组成从 *t* 年到 *t*+1 年没有变化的公司中，这种类型的公司董事网络结构洞的变化主要来源于网络中其它公司董事的变化或者该公司董事在其它公司任职情况的变化（Larcker *et al.*, 2013），所以，其网络结构洞变化更不可能源于公司决定或改变董事会构成而产生的内生选择。加上在中国独立董事是董事网络形成的主要力量（谢德仁和陈运森，2012），就单独选取了“独立董事不变、所有董事不变的样本”两类样本进行检验来降低内生性的影响。表 8 的结果是在选取“独立董事不变、所有董事不变的样本”的基础上，同时使用了 change 模型（前四列）和 level 模型（后四列），尤其是 change 模型更不受内生性的影响。从前四列的结果可以发现，结构洞网络位置的变化与“商业信用-现金持有”的变化关系显著，但与商业信用获取额的变化不显著，而后四列的结果中，除了在“所有董事不变样本”中结构洞位置对商业信用获取不显著，其它三列的结果都符合预期。

3、为了检验社会网络分析常用的网络中心度指标（主要衡量网络的关系性特征）与结构洞指标（主要衡量网络的结构嵌入性特征）对商业信用获取和使用的作用差异，本文借鉴 Freeman（1979）、Wasserman and Faust（1994）、Larcker *et al.*（2013）介绍的网络中心度指标，按照谢德仁和陈运森（2012）的定义，基于所有董事的兼任关系（与本文所定义的董事网络一致）计算了公司董事网络的程度中心度、中介中心度、

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[14] 正如 Larcker *et al.*（2013）在文中所指出的，此类研究并不能排除所有可能的因果解释等内生性问题，只能通过几种方法来试图降低内生性的影响。

表 6　稳健性检验（1）

	1	2	3	4	5	6
	TC3_adj	*TC3_adj*	同期	同期	固定效应模型	
TC		0.045		0.503***		0.291***
		(0.88)		(22.79)		(11.61)
*CI*TC*		-0.176**		-0.227***		-0.150***
		(-2.05)		(-4.49)		(-3.06)
CI	0.009***	0.006	0.003*	-0.003	0.001	0.013*
	(2.85)	(0.54)	(1.73)	(-0.41)	(0.39)	(1.80)
SIZE	0.011***	-0.007	0.017***	-0.019***	-0.018***	-0.040***
	(10.90)	(-1.61)	(17.47)	(-9.32)	(-10.16)	(-10.01)
LEV	0.173***	-0.213***	0.073***	-0.335***	0.061***	-0.102***
	(42.20)	(-9.53)	(18.33)	(-40.27)	(10.97)	(-8.41)
MB	-0.007***	0.027***	-0.001	0.015***	-0.001	0.020***
	(-5.46)	(4.77)	(-0.40)	(5.57)	(-0.80)	(6.76)
INV	-0.187***	-0.405***	0.052***	-0.604***	0.021***	-0.340***
	(-37.99)	(-16.29)	(10.79)	(-60.45)	(3.46)	(-25.57)
OCF	0.176***	0.468***	0.189***	0.544***	0.065***	0.248***
	(15.44)	(10.32)	(16.77)	(23.24)	(6.51)	(11.37)
SOE	0.013***	0.018**	0.005**	0.002	-0.003	0.021***
	(6.77)	(2.30)	(2.57)	(0.43)	(-1.15)	(3.16)
POST	-0.015***	0.021**	0.022***	-0.006	0.026***	0.057***
	(-3.74)	(1.98)	(5.03)	(-0.64)	(8.09)	(7.96)
CONS	-0.211***	0.557***	-0.443***	1.031***	0.341***	1.183***
	(-9.46)	(5.90)	(-20.31)	(22.72)	(8.77)	(13.86)
YEAR/IND	√	√	√	√	√	√
R-sqr	0.236	0.222	0.111	0.354	0.061	0.136
F-Value	106.63	19.52	47.26	196.92	42.98	91.72
Obs.	12098	12096	13681	13678	12064	12062

注：括号内为 t 值，*、**、***分别表示在 10%、5%和 1%水平下显著；结果经过公司层面的 Cluster 调整。

表 7　稳健性检验（2）：结构洞的影响因素模型

	因变量：下一期 *CI*
TC	0.024
	(0.92)
ROA	-0.000***
	(-9.18)
SIZE	0.001
	(0.40)
LEV	-0.077***
	(-6.24)
MB	-0.031***
	(-9.69)
SOE	0.029***
	(4.91)
BOARD	0.023***
	(16.62)
OUT	0.129***
	(5.19)
DUAL	-0.022***
	(-2.80)
CONS	0.093
	(1.46)
YEAR/IND	√
R-sqr	0.060
F-Value	30.35
Obs.	11976

注：括号内为 t 值，*、**、***分别表示在 10%、5%和 1%水平下显著；结果经过公司层面的 Cluster 调整。

表 8　稳健性检验（3）

	所有董事不变样本		独立董事不变样本		所有董事不变样本		独立董事不变样本	
	因变量：*ΔTC*	因变量：*△CASH*	因变量：*ΔTC*	因变量：*ΔCASH*	因变量：*TC*	因变量：*CASH*	因变量：*TC*	因变量：*CASH*
ΔCI	-0.003	0.005	0.000	0.001				
	(-0.46)	(0.34)	(0.01)	(0.13)				
ΔTC		0.253***		0.246***				
		(5.57)		(7.83)				
*ΔCI*ΔTC*		-0.162*		-0.112*				
		(-1.79)		(-1.81)				
CI					0.001	0.000	0.010**	0.004
					(0.15)	(0.02)	(2.05)	(0.46)
TC						0.415***		0.380***
						(8.44)		(10.60)
*CI*TC*						-0.179*		-0.152*
						(-1.69)		(-1.96)
SIZE	-0.003**	-0.007**	-0.003***	-0.006**	0.014***	-0.010**	0.015***	-0.010***
	(-2.19)	(-2.19)	(-2.85)	(-2.41)	(7.02)	(-2.46)	(9.95)	(-3.28)
LEV	-0.005	0.071***	0.002	0.059***	0.114***	-0.220***	0.119***	-0.215***
	(-0.81)	(4.91)	(0.51)	(5.77)	(13.12)	(-11.68)	(18.53)	(-16.36)
MB	0.002	0.007*	0.000	0.005*	-0.002	0.033***	-0.005**	0.031***
	(1.00)	(1.80)	(0.12)	(1.69)	(-0.79)	(6.04)	(-2.42)	(7.62)
INV	-0.001	0.112***	-0.008	0.112***	0.036***	-0.415***	0.010	-0.389***
	(-0.09)	(6.65)	(-1.50)	(9.11)	(3.61)	(-19.56)	(1.57)	(-25.43)
OCF	-0.062***	-0.089**	-0.051***	-0.096***	0.128***	0.478***	0.155***	0.425***
	(-4.01)	(-2.26)	(-4.26)	(-3.35)	(5.39)	(9.49)	(8.59)	(11.91)
SOE	0.002	0.008	0.003*	0.004	0.002	0.038***	0.004	0.023***
	(0.60)	(1.32)	(1.74)	(0.90)	(0.62)	(4.73)	(1.38)	(3.89)
POST	-0.003	0.015**	-0.002	0.016***	0.031**	0.017	0.039***	0.025
	(-0.94)	(2.09)	(-1.02)	(3.08)	(2.48)	(0.66)	(11.14)	(1.28)
CONS	0.066**	0.039	0.063***	0.027	-0.395***	0.607***	-0.403***	0.624***
	(2.39)	(0.56)	(2.97)	(0.53)	(-8.69)	(6.25)	(-12.65)	(8.98)
YEAR/IND	√	√	√	√	√	√	√	√
R-sqr	0.014	0.045	0.009	0.039	0.118	0.243	0.130	0.234
F-Value	1.68	5.11	1.98	8.12	11.63	26.46	104.70	47.02
Obs.	3149	3147	5848	5846	2998	2998	5592	5592

注：括号内为 t 值，*、**、***分别表示在 10%、5%和 1%水平下显著；结果经过公司层面的 Cluster 调整。

接近中心度和特征向量中心度的综合指标 *Cen*。[15] 并进行如下三类分析：首先，通过网络中心度指标和结构洞指标的相关系数分析得知：*Cen* 与 *CI* 的 Pearson 相关系数为 0.52、Spearman 相关系数为 0.54，说明两者相关性并不是非常高；其次，把 *Cen* 作为控制变量放入模型，结果显示无论是商业信用获取模型还是商业信用使用模型，*Cen* 本身并不显著，且对 *CI* 的结果影响不大，结果见表 9 的前两列（两个模型中 *Cen* 的 t 值分别为 -0.24 和 1.41）；再次，如果把网络中心度（*Cen*）代替结构洞（*CI*）的放入模型中，对商业信用获取（*TC*）的系数不显著（t 值为 -0.04），当因变量为现金持有（*CASH*）时，*Cen*TC* 的系数甚至是显著为正的（t 值为 1.82），结果见表 9 的后两列。上述三类检验说明从实证的角度来看，结构洞指标和网络中心度指标存在差异，结构洞指标对商业信用的影响要强于网络中心度指标，与 Zaheer and Bell（2005）的发现类似。这也从实证的角度突出了结构洞网络位置对商业信用的重要作用。[16]

4、本文主要研究发现结构洞网络关系对商业信用具有影响，那么在那些具有典型商业信用链条的行业、董事网络构成跨行业的公司是否结果依然存在？我通过三方面检验对此进行探讨：（1）由于本文的主要逻辑是基于董事网络的结构洞位置所能获得的信息优势和控制优势，那么对于那些同时位于不同行业的兼任董事所产生的董事网络样本中应该也能够观察到，为了进一步研究公司产生网络联结的直接动因 － 连锁董事 － 是否处于不同的行业是否同样有结果，我单独选取了兼任董事跨行业的两类细分样本：如果公司有董事在其它公司同时任职且所任职公司与该公司不属于同一行业则 *INTERIND* = 1；如果公司的所有兼任董事所任职公司与该公司都不属于同一行业则 *INTERINDALL* = 1，其中第二个指标范围限制更加严格。两个子样本的结果显示结论不会发生变化，见表 10 的前四列，第一和第三列显示 *CI* 在 10%水平下显著正相关，第二列和第四列显示 *CI*TC* 在 1%水平下显著负相关（未报告的结果显示 *INTERIND* =0 和 *INTERINDALL* = 0 两组样本的细分结果也存在，同时也对存在兼任董事的那些公司样本（结构洞网络位置的发起者）进行了检验，结果也依然存在）；（2）由于商业信用隐含的一个因素是不同行业上下游之间的关系，但现有基于大样本数据的商业信用研究都无法直接找出两两对应的商业信用契约公司。龚柳元和毛道维（2007）发现，位于产业价值链上游的资源类及下游销售类行业拥有一些关键资源，这些行业中的企业更少提供商业信用，更易成为商业信用净获得者，此外，由于制造业的上下游产业链特征也比较明显，我选取了制造业、资源行业和零售行业三个行业的公司（*INDALL* =1）样本来进行细分研究，结果见表 10 的第五、六列（未报告的结果中，还把三个样本分别进行检验，在制造业和零售业的结果显著）；（3）同时选取了公司所有兼任董事均处于不同行业（*INTERINDALL* = 1）以及三个细分行业样本（*INDALL* = 1）的综合，结果见表 10 的最后两列，*CI* 在 10%水平下显著正相关，*CI*TC* 在 10%水平下显著负相关。以上三个检验从实证的细分角度对本文“结构洞网络位置影响商业信用”逻辑形成了进一步佐证。

5、此外，我还做了如下稳健性检验（篇幅所限，结果未提供）：（1）商业信用变

[15] 详细计算方法烦请参见谢德仁和陈运森（2012）。

[16] 如果本文逻辑更多地体现在闭合网络逻辑中，那么网络中心度指标（主要衡量了闭合网络的强度）可能更加显著，然而表 9 的结果显示，网络中心度指标并不显著，再一次说明在本文商业信用的逻辑主要基于结构洞位置而非闭合网络；同时，后续进一步研究中发现的结构洞位置的作用更多体现在信息环境较差的公司以及货币政策宽松时期的结果也验证了这一结论。

量可能包括公司与其关联方之间的业务，为了降低这种行为对论文结果的影响，区分了是否与关联公司之间有“商品交易类、提供或接受劳务、资金交易”三种可能影响商业信用合约的两组样本（*RPT*），若有则 $RPT = 1$，否则 $RPT = 0$。结果显示按照关联交易行为分组后结果在两类样本都依然显著，说明本文结论不因关联交易而产生影响；（2）一般来说，中国公司通常涉及到母公司或控股公司的问题，即公司高管同时会在母公司任董事。此时因变量的商业信用与自变量“结构洞”之间的关系，可能是与控股公司向上市公司派驻董事的关系。但是，本文中董事网络的构建是依据于上市公司之间的董事兼任产生的网络，此现象在满足母子公司都是上市公司且母公司派驻董事到子公司两个条件时会出现，但就作者的了解，母子公司都是上市公司的情况较少见，如果再加上第二个条件的公司就会再少些，本文的大样本数据应该不会受此影响。当然为了结果的稳健，我把当年存在大股东兼任董事（定义为：若公司的董事同时也在第一大股东单位或者实际控制人单位任职则定义为 1，否则为 0）的公司观测剔除，[17] 仅用非大股东兼任董事的公司样本进行回归，主要结果不变。

表 9　结构洞指标与网络中心度指标的对比分析

	(1) 因变量：*TC2_adj*	(2) 因变量：*CASH*	(3) 因变量：*TC2_adj*	(4) 因变量：*CASH*
TC		0.41***		0.33***
		(11.73)		(11.19)
Cen	-0.00019	0.0024	-0.000033	0.0018
	(-0.24)	(1.41)	(-0.04)	(1.22)
CI	0.0034*	-0.0061		
	(1.69)	(-0.53)		
*CI*TC*		-0.19***		
		(-2.93)		
*Cen*TC*				0.017*
				(1.82)
SIZE	0.015***	-0.013***	0.015***	-0.015***
	(7.07)	(-3.13)	(7.28)	(-3.50)
LEV	0.075***	-0.24***	0.077***	-0.25***
	(8.11)	(-11.26)	(8.52)	(-11.94)
MB	-0.0025	0.028***	-0.0026	0.027***
	(-1.02)	(4.84)	(-1.08)	(4.74)
INV	0.042***	-0.42***	0.042***	-0.44***
	(4.06)	(-18.28)	(4.17)	(-18.81)
OCF	0.15***	0.41***	0.15***	0.43***
	(9.13)	(9.41)	(9.42)	(10.06)
SOE	0.0074*	0.015**	0.0080**	0.013*
	(1.84)	(2.03)	(2.03)	(1.73)
POST	0.013***	0.013	0.014***	0.028***
	(3.35)	(1.24)	(3.08)	(2.88)
CONS	-0.39***	0.72***	-0.39***	0.77***
	(-8.45)	(7.45)	(-8.74)	(7.89)
YEAR/IND	√	√	√	√
R-sqr	0.092	0.243	0.093	0.257
F-Value	14.2	23.3	18.5	22.1
Obs.	12032	12030	12521	12495

注：括号内为 t 值，*、**、***分别表示在 10%、5%和 1%水平下显著；结果经过公司层面的 Cluster 调整。

[17] 感谢西南财经大学会计学院郑皋娉博士分享此数据。

表 10　细分行业和细分董事的结果

	INTERIND=1	*INTERIND*=1	*INTERINDALL*=1	*INTERINDALL*=1	*INDALL*=1	*INDALL*=1	*INTERINDALL*=1 & *INDALL*=1	*INTERINDALL*=1 & *INDALL*=1
	因变量：*TC2_adj*	因变量：*CASH*	因变量：*TC2_adj*	因变量：*CASH*	因变量：*TC2_adj*	因变量：*CASH*	因变量：*TC2_adj*	因变量：*CASH*
TC		0.44***		0.45***		0.42***		0.44***
		(14.22)		(12.71)		(14.68)		(10.01)
*CI*TC*		-0.23***		-0.21***		-0.21***		-0.16*
		(-3.71)		(-2.76)		(-3.17)		(-1.88)
CI	0.0067*	0.0047	0.0091*	0.0078	0.0037*	0.0053	0.0051*	0.017
	(1.83)	(0.57)	(1.87)	(0.78)	(1.75)	(0.64)	(1.73)	(1.32)
SIZE	0.015***	-0.013***	0.016***	-0.016***	0.015***	-0.0064**	0.017***	-0.0073*
	(11.93)	(-4.99)	(10.34)	(-5.00)	(10.69)	(-2.38)	(7.81)	(-1.81)
LEV	0.078***	-0.25***	0.080***	-0.26***	0.10***	-0.22***	0.095***	-0.25***
	(14.50)	(-23.53)	(12.78)	(-19.90)	(16.36)	(-18.61)	(10.33)	(-14.43)
MB	-0.0024	0.025***	0.00056	0.027***	-0.0037*	0.027***	0.0024	0.024***
	(-1.34)	(7.16)	(0.28)	(6.50)	(-1.80)	(7.20)	(0.85)	(4.50)
INV	0.043***	-0.42***	0.047***	-0.45***	0.025***	-0.45***	0.050***	-0.45***
	(6.71)	(-33.58)	(6.33)	(-29.43)	(3.53)	(-34.73)	(4.79)	(-22.95)
OCF	0.14***	0.41***	0.13***	0.40***	0.17***	0.47***	0.13***	0.41***
	(9.22)	(13.93)	(7.51)	(11.09)	(10.01)	(14.55)	(5.19)	(8.36)
SOE	0.0084***	0.011**	0.010***	0.014**	0.012***	0.0046	0.016***	-0.0073
	(3.42)	(2.21)	(3.51)	(2.37)	(4.22)	(0.90)	(3.98)	(-0.95)
POST	0.0082	0.026**	0.0086	0.055***	0.0096	0.025**	-0.0076	0.078***
	(1.36)	(2.04)	(1.24)	(3.86)	(1.49)	(2.12)	(-0.77)	(4.19)
CONS	-0.39***	0.73***	-0.41***	0.82***	-0.39***	0.57***	-0.43***	0.60***
	(-13.70)	(12.86)	(-11.89)	(11.57)	(-12.41)	(9.64)	(-9.25)	(6.73)
YEAR/IND	√	√	√	√	√	√	√	√
R-sqr	0.096	0.254	0.100	0.260	0.102	0.235	0.108	0.238
F-Value	25.8	75.9	19.4	56.0	50.3	119.3	24.7	54.9
Obs.	8126	8124	5796	5795	6917	6917	3116	3116

注：括号内为 t 值，*、**、***分别表示在 10%、5%和 1%水平下显著；结果经过公司层面的 Cluster 调整。

（四）进一步分析[18]

在前述回归分析中发现公司董事网络的结构洞位置会影响公司的商业信用的获取和使用，进一步分析中通过公司信息环境、公司规模和上市年龄、是否货币政策紧缩期等进行细分样本研究：

1、为了进一步从公司层面来探究结构洞网络位置对商业信用及其使用成本的影响，我区分不同公司信息环境的差异。用分析师跟踪人数作为公司信息环境（*INFO*）的代理变量（Armstrong *et al.*, 2010），若 *t* 年跟踪该公司的分析师人数位于当年所有分析师跟踪人数中位数以上，则认为公司信息环境较好，即 $INFO = 1$，否则 $INFO = 0$。表 11 的结果显示，公司信息环境对于结构洞与商业信用数量的关系不显著，但结构洞与商业信用使用成本的负相关关系在 $INFO = 0$ 组别中显著（显著性水平为 1%），而在 $INFO = 1$ 组别不显著，说明结构洞位置对商业信用使用成本的作用主要体现在信息环境较差的公司中。由于结构洞位置强调的是对非冗余信息的优势，那么相对于信息环境较差的公司，在信息环境较好的公司中，利益相关者掌握的信息在某种程度上是冗余的公开信息，此时结构洞位置对决策行为的影响就相对较弱；而对于信息环境较差的公司的外部决策者而言，由于公司内部披露的或者外部能低成本获得的信息较少，某种意义上冗余信息的公开也较低，那么通过丰富结构洞网络获得的关键性非冗余信息的作用就更加显现。整体而言，结论说明结构洞所体现的信息优势与公司信息环境是替代关系。

2、我还区分了公司规模（*DSIZE*）和上市年龄（*DAGE*）进行检验，按年份和行业计算公司规模的中位数，若该公司的规模位于中位数之上则 $DSIZE = 1$，否则 $DSIZE = 0$；若公司上市年龄为 2 年以上则定义 $DAGE = 1$，否则 $DAGE = 0$（如果按上市年龄 3 年区分，结果也类似）。分样本的结果如表 12 显示：结构洞与商业信用获取的关系主要在规模较大公司中存在、结构洞与商业信用使用成本的关系主要在规模较大的公司和上市年龄较久的公司存在。可能的原因为：网络作用的发挥会受行动者特质的影响（Burt, 1992），而企业的禀赋是结构洞网络作用发挥的“特质性”因素，对于规模较小的公司和年轻公司而言，供应商更看重的是公司的其它更基本和重要的特质（如公司规模和上市年龄）而非网络位置。在规模较大及比较成熟的公司中，最基本和稳定的“供应商-客户”关系容易建立起来，在此基础上供应商则会进一步考虑公司除基本信任之外的其它缔约所依赖的因素，基于董事网络的结构洞位置便可能是其考虑的因素之一，在此背景下董事网络的结构自主性将更强（Structural Autonomy）。本文结果发现结构洞位置所体现的在供应商-客户的商业信用契约中的作用与公司规模和上市年龄是替代作用。

3、由于商业信用及其使用成本与外部经济环境密切相关，借鉴饶品贵和姜国华（2013），设定 *MP* 为货币政策紧缩阶段虚拟变量，如果年份为 2004、2006、2007 和 2010，则 $MP = 1$，否则 *MP* 为 0。结果如表 13 所示，在货币政策宽松时期（$MP = 0$ 组），

[18] 感谢匿名审稿人的宝贵建议。

表 11 信息环境、结构洞与商业信用

	$INFO=0$	$INFO=1$	$INFO=0$	$INFO=1$
	因变量：*TC2_adj*	因变量：*TC2_adj*	因变量：*CASH*	因变量：*CASH*
TC			0.41***	0.39***
			(15.37)	(7.82)
*CI*TC*			-0.20***	-0.091
			(-3.39)	(-0.81)
CI	0.0016	0.0087	0.0064	-0.031**
	(0.46)	(1.04)	(0.89)	(-1.97)
SIZE	0.014***	0.018***	-0.013***	-0.0090*
	(12.32)	(6.86)	(-5.37)	(-1.80)
LEV	0.072***	0.095***	-0.23***	-0.29***
	(14.98)	(9.29)	(-23.51)	(-14.56)
MB	-0.0026	-0.0034	0.029***	0.023***
	(-1.62)	(-1.01)	(8.87)	(3.66)
INV	0.046***	0.022*	-0.44***	-0.34***
	(8.05)	(1.73)	(-37.35)	(-14.13)
OCF	0.14***	0.16***	0.44***	0.29***
	(10.49)	(5.52)	(16.30)	(5.32)
SOE	0.0083***	0.0069	0.017***	0.0097
	(3.74)	(1.41)	(3.86)	(1.05)
POST	0.015***	-0.020*	0.057***	0.032
	(3.19)	(-1.94)	(5.93)	(1.51)
CONS	-0.38***	-0.43***	0.72***	0.59***
	(-14.57)	(-7.20)	(13.56)	(5.24)
YEAR/IND	√	√	√	√
R-sqr	0.089	0.135	0.247	0.237
F-Value	28.7	10.4	89.0	18.7
Obs.	6951	5112	6951	5112

注：括号内为 t 值，*、**、***分别表示在 10%、5%和 1%水平下显著；结果经过公司层面的 Cluster 调整。

结构洞位置与商业信用获取和商业信用使用成本的关系都是符合预期，但在货币政策紧缩时期（$MP=1$ 组）结果不再显著。可能的解释有两个：首先，陆正飞和杨德明（2011）发现在商业信用货币政策宽松时期符合买方市场理论，货币政策紧缩时期更属于替代性融资理论。这说明结构洞与商业信用的结果主要产生在货币政策宽松年份的可能原因是，在货币政策宽松时期，商业信用更多地产生于企业正常购销活动，结构洞网络位置而产生的信息优势和控制优势更多地作用于这种基于买方市场理论而产生的商业信用（本文的主要逻辑即是基于买方市场理论的商业信用），然而在货币政策紧缩时期，商业信用更多地用于替代性融资，在此情况下由于所有企业都面临资金面上的压力，网络结构不能再发挥其优势。其次，与闭合性网络（Closure）强调强联结关系所产生的信任和规范不同，结构洞位置更多体现的是“弱联结”的优势，强调在不同子网络担任“桥梁”的作用。在货币政策紧缩时期，外部的融资环境更加恶化，基于市场的自由交易规则被外界政策所干扰，此时强联结关系产生的网络成员之间的信任则更加重要，结构洞位置的作用相对而言要弱一些；相反地，在货币政策宽松时期，“供应商-客户”的交易行为相对而言不受外界宏观政策的影响，此时基于非冗余信息的结构洞

表 12　结构洞与商业信用：基于公司规模和上市年龄的检验

	DSIZE=0	*DSIZE*=1	*DSIZE*=0	*DSIZE*=1	*DAGE*=0	*DAGE*=1	*DAGE*=0	*DAGE*=1
	TC2_adj	*TC2_adj*	*CASH*	*CASH*	*TC2_adj*	*TC2_adj*	*CASH*	*CASH*
TC			0.42***	0.38***			0.35***	0.39***
			(11.89)	(12.90)			(4.28)	(16.21)
*CI*TC*			-0.11	-0.27***			0.16	-0.19***
			(-1.33)	(-4.28)			(0.85)	(-3.59)
CI	0.0025	0.0012*	0.0086	-0.0049	0.0072	0.0015	-0.00014	0.00085
	(0.51)	(1.89)	(0.78)	(-0.66)	(0.92)	(0.42)	(-0.01)	(0.12)
SIZE	0.021***	0.0075***	-0.038***	0.0023	0.013***	0.016***	-0.0042	-0.0062***
	(7.71)	(4.02)	(-6.16)	(0.72)	(4.11)	(14.18)	(-0.55)	(-2.75)
LEV	0.059***	0.11***	-0.26***	-0.23***	0.10***	0.082***	-0.48***	-0.20***
	(10.39)	(14.09)	(-20.51)	(-17.32)	(6.15)	(17.63)	(-12.36)	(-21.92)
MB	0.00017	-0.012***	0.019***	0.031***	0.0075	-0.0020	0.014	0.032***
	(0.08)	(-4.57)	(4.19)	(6.74)	(1.07)	(-1.32)	(0.86)	(11.09)
INV	0.058***	0.035***	-0.44***	-0.40***	0.051***	0.047***	-0.76***	-0.35***
	(7.64)	(4.68)	(-26.25)	(-30.78)	(3.52)	(8.33)	(-22.42)	(-32.27)
OCF	0.14***	0.15***	0.37***	0.46***	0.16***	0.14***	0.60***	0.40***
	(8.24)	(8.79)	(9.72)	(15.67)	(4.82)	(11.09)	(7.39)	(15.84)
SOE	0.0060**	0.0071**	0.018***	0.016***	0.0059	0.0083***	0.013	0.019***
	(2.10)	(2.54)	(2.81)	(3.31)	(1.16)	(3.80)	(1.11)	(4.58)
POST	0.019***	0.0017	0.039**	0.037***	-0.015*	0.012**	0.030	0.022**
	(2.86)	(0.31)	(2.51)	(3.76)	(-1.74)	(2.47)	(1.45)	(2.23)
CONS	-0.53***	-0.21***	1.24***	0.38***	-0.37***	-0.42***	0.83***	0.51***
	(-8.93)	(-5.22)	(9.48)	(5.42)	(-5.29)	(-16.26)	(4.97)	(10.03)
YEAR/IND	√	√	√	√	√	√	√	√
R-sqr	0.090	0.087	0.230	0.284	0.109	0.103	0.413	0.217
F-Value	18.0	17.3	49.6	65.5	6.82	35.4	32.6	79.7
Obs.	6033	6030	6031	6030	1571	10492	1571	10490

注：括号内为 t 值，*、**、***分别表示在 10%、5%和 1%水平下显著；结果经过公司层面的 Cluster 调整。

位置则能充分发挥其“信息优势”和“控制优势”的优势，即在货币政策宽松时期更能体现结构洞位置的作用。

4、此外，如果结构洞网络位置对企业商业信用获取和使用有正向作用，那么一个合理的拓展便是未来是否提升了公司业绩。我分别用了行业调整后的总资产收益率（*ROA*）、净资产收益率（*ROE*），以及经大盘调整后的年度股票收益（*RET*）作为公司业绩的代理变量，结果显示：[19] 在未来一年中，无论是 *ROA_adj*、*ROE_adj* 还是 *RET*，都显著正相关（系数在 5%或 1%水平下显著），未来两年后，*ROA_adj* 系数不显著，*ROE_adj* 和 *RET* 显著性降低，而且系数也减少。整体结果说明，结构洞网络位置确实给公司带来了未来业绩的提升。

表 13　货币政策、结构洞与商业信用

	MP=0	*MP*=1	*MP*=0	*MP*=1
	因变量：*TC2_adj*	因变量：*TC2_adj*	因变量：*CASH*	因变量：*CASH*
TC			0.44***	0.37***
			(15.10)	(9.28)
*CI*TC*			-0.25***	-0.060
			(-3.77)	(-0.69)
CI	0.0010*	-0.0042	0.00075	-0.0083
	(1.74)	(-0.95)	(0.09)	(-0.88)
SIZE	0.018***	0.014***	-0.0078***	-0.012***
	(13.49)	(11.02)	(-2.99)	(-4.39)
LEV	0.063***	0.098***	-0.23***	-0.25***
	(10.77)	(15.90)	(-20.55)	(-18.65)
MB	0.0029	0.0030**	0.040***	0.019***
	(1.62)	(2.10)	(11.52)	(6.31)
INV	0.015**	0.0077	-0.40***	-0.39***
	(2.47)	(1.19)	(-33.41)	(-28.18)
OCF	0.15***	0.11***	0.39***	0.52***
	(9.30)	(6.15)	(12.26)	(13.74)
SOE	0.0051*	0.0075**	0.015***	0.017***
	(1.88)	(2.57)	(2.92)	(2.81)
CONS	-0.44***	-0.37***	0.58***	0.71***
	(-15.04)	(-13.03)	(10.25)	(11.51)
IND	√	√	√	√
R-sqr	0.066	0.084	0.223	0.224
F-Value	71.5	65.3	216.6	167.6
Obs.	6915	5148	6914	5147

注：括号内为 t 值，*、**、***分别表示在 10%、5%和 1%水平下显著；结果经过公司层面的 Cluster 调整。

五、 结论与不足

社会网络理论认为，行动者和他们的行动被视为相互依赖的，而不是相互独立和自治的个体，而且行动者之间的关系是资源转移或“流动”的通道。在产品竞争市场上，企业也处于社会网络之中，但从社会网络特别是网络结构观点来研究企业活动一

[19] 进一步相关分析见陈运森（2015）。

直被忽视，正如 Wasserman and Faust（1994）所说，基于社会网络的社会资本虽然最容易受到忽略，但它却是决定竞争成败的关键因素。从社会网络的结构洞观点来看，核心战略网络能给企业带来控制优势和信息优势，进而增强企业在产品竞争市场的实力，而商业信用获取和使用作为企业在竞争中的重要体现，成为检验结构洞网络位置对企业竞争影响的极佳视角。本文则通过对企业决策具有重要影响的董事/高管的个体共同任职关系构建社会网络，并基于该网络研究企业结构洞网络位置与商业信用获取和使用的关系。结果发现，企业所处的网络结构洞越丰富，能够获取的商业信用就越多，从而增强了其在产品市场的竞争优势，同时结构洞越丰富的企业“商业信用-现金持有”敏感性越低，即商业信用的使用成本越低；进一步研究发现，结构洞位置与商业信用获取和使用成本的影响在竞争更为激烈的行业以及市场发展更充分的地区更加显著，这说明商业信用作为一种基于市场的契约，企业网络位置对其的作用在市场化因素下更强。此外还发现，结构洞网络位置对商业信用的影响更多地存在于信息环境较差、规模较大、上市年龄较久的公司中，且更多地存在于货币政策宽松时期。本文的结论无论对于扩展现有基于企业个体特征为主要切入点公司财务研究，还是对现实中解决企业如何通过商业信用来获取产品市场竞争优势的关键问题都具有较大的启示意义。

本文也有一些不足。首先，由于商业信用的衡量是基于不同产业链条层级（即不同行业）的一种契约关系，尽管在稳健性检验中通过细分样本（考虑董事的跨行业性、具有典型商业信用链条的行业以及两者综合）进行了考虑，但还是不能较为直观地指出公司结构洞网络位置与居于不同产业链条的企业形成的商业信用的直接逻辑关系，这也是多数商业信用文献面临的一个问题，希望在未来研究中能够加以考虑；其次，本文可能存在一定的内生性问题，尽管在稳健性检验中通过多种方法试图降低内生性的干扰，但还是没法完全排除该问题的影响，正如 Larcker *et al.*（2013）所指出的，此类研究并不能排除所有可能的因果解释等内生性问题，只能通过几种方法来试图降低内生性的影响。

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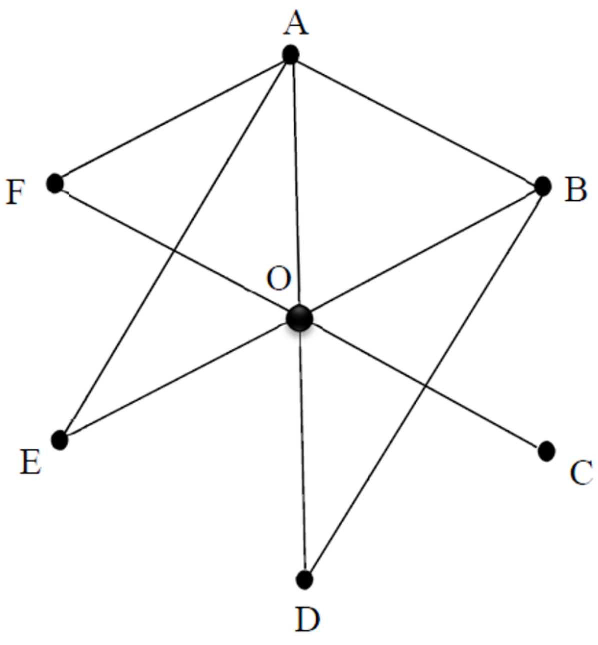
附录　结构洞网络位置的衡量方法

如正文所述，我通过网络约束指数来衡量结构洞位置：

$$C_{ij}=(p_{ij}+\sum_{q}p_{iq}p_{jq})^2$$

其中 C_{ij} 是企业 i 与企业 j 接触联系所需关系投资的约束程度，受两部分的影响：P_{ij} 等于企业 i 到企业 j 的直接连带关系的强度（如果某董事同时在 i 和 j 任职，那么就认为这两个公司有直接连带关系），衡量的是企业 i 在 j 中的直接关系投资，而 $\sum_{q}p_{iq}p_{jq}$ 等于从 i 到 j 的所有通过 q 的路径中，（路径为 2 的）非直接连带关系的强度之和，衡量的是企业 i 在企业 j 身上的间接关系投资。为了理解的方便，用 1 与“约束指数”的差来衡量结构洞丰富程度（Burt, 1992; Zaheer and Bell, 2005）：$CI_i=1-C_{ij}$，如果 CI_i 越大，就表明网络约束越小，网络结构洞越丰富。

为了更好地理解本文指标的算法，受 Burt（2008）启发，绘制下图来解释上述指标：



附图 1　结构洞位置衡量示例图

上图的网络中有 7 个参与者：O、A、B、C、D、E、F，两个参与者之间的线条表明两者之间有直接的联结关系，把这张图的直接联结关系矩阵化，就可以得出下表：

附表 1　不同参与者关系的矩阵表

	A	B	C	D	E	F	O
A	·	1	0	0	1	1	1
B	1	·	0	1	0	0	1
C	0	0	·	0	0	0	1
D	0	1	0	·	0	0	1
E	1	0	0	0	·	0	1
F	1	0	0	0	0	·	1
O	1	1	1	1	1	1	·

首先，结合附图 1 来介绍参与者 O 的结构洞网络位置计算方法：图中 6 个点对 O 的约束程度的计算有两部分：直接联系占用的时间/精力以及（路径为 2 的）间接联系占用的时间/精力两部分。我选取具有代表性的 C_{OC}、C_{OD}、C_{OB} 三个网络约束指数（计算 O 的整个网络约束指数的其中一部分）来进行说明：

C_{OC} 的计算步骤：从图可以看出，O 总共在网络中有 6 条直接联系路径，但 C 跟 O 仅有一条直接联系，且没有间接联系的路径，那么 C_{OC} 就等于 C 与 O 直接联系的路径占用 O 总的直接联系路径和的程度：$(1/6)^2 = 0.028$。

C_{OD} 的计算步骤：与 O-C 相同的是，O 总共有 6 条直接联系路径，D 跟 O 仅有一条直接联系，那么差异就在于 O-D 还有间接联系路径：O-B-D。那么 B 作为传导人所控制的这一间接联系的程度就等于 O-B 的控制程度乘于 D-B 的控制程度。其中 P_{OB} 为 1（B 和 O 有一条直接联系路径）除以 6（O 总共有六条直接联系路径），即 1/6，同理 P_{BD} 为 1（B 和 D 有一条直接联系路径）除以 3（B 总共有三条直接联系路径），即 1/3，那么 O 和 D 的间接联系路径程度为 $(1/6 * 1/3) = 1/18$，所以 $C_{OD} = (1/6 + 1/18)^2 = 0.049$。

C_{OB} 的计算步骤：O-B 的直接联系程度跟前两个情况都类似，但间接联系有 O-A-B 和 O-D-B 两种路径，O-B 的间接联系受约束程度为这两个路径约束程度之和，与上述算法类似，为 $(1/6*1/4) + (1/6*1/2) = 1/8$，所以 $C_{OB} = (1/6+1/8)^2 = 0.085$。

C_{OA}、C_{OE} 和 C_{OF} 的计算方法类似，不一一重复，具体结果见下表。

附表 2　C_{ij} 的计算方法示例

C_{ij}	C_{OA}	C_{OB}	C_{OC}	C_{OD}	C_{OE}	C_{OF}	$C_O = C_{OA} + C_{OB} + C_{OC} + C_{OD} + C_{OE} + C_{OF}$
Value	0.151	0.085	0.028	0.049	0.043	0.043	0.399

在计算了 O 与图中每一个点的约束程度之后，再（根据公式 $C_i = \Sigma_j C_{ij}$）加总则可得 O 在该网络中的总网络约束指数：$C_O = C_{OA} + C_{OB} + C_{OC} + C_{OD} + C_{OE} + C_{OF} = 0.399$。

得出参与者 O 的网络约束指数之后，根据公式 $CI_i = 1 - C_{ij}$，最后可求出参与者 O 的结构洞丰富程度：$CI_O = 1 - 0.399 = 0.601$。

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Social Network and Trade Credit: Evidence Based on Structural Holes*

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Abstract

A firm's social network can provide it with competitive advantage, while its trade credit may reflect the competitiveness of its business operations. Unfortunately, there is a lack of crossover studies looking at both social networks and business credit. This paper investigates the influence of a firm holding different structural hole positions on its trade credit. By defining networks as directors' interlocking positions and using social network analysis to compute the structural holes, this study demonstrates empirically that firms with more structural holes get more trade credit, thereby enhancing their competitive advantage in the market, and their trade credit-cash sensitivity also decreases. These results hold after controlling for the endogeneity problem and the influence of a network centrality measure. Additional analyses show that the influence of structural hole position on trade credit is more obvious in highly competitive industries and regions that have a higher level of marketisation. Moreover, the effect is found mainly for larger and more mature firms and those situated in a worse information environment, and often manifests during a time of loose monetary policies. The results suggest that the control and information advantages obtained by positioning in structural holes are important in enabling firms to obtain trade credit, which can enhance their competitive advantage. The conclusions contribute to the literature on social network and corporate finance.

Keywords: Structural Holes, Social Network, Board Network, Trade Credit, Product Market Competition
CLC codes: F275, F224, F230

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I. Introduction

The economic behaviour of firms is embedded in the social network (Granovetter, 1985) and business activities are conducted in certain competitive arenas. Accordingly, the competitive advantage obtained by firms in market competition demonstrates not only resource superiority, but also confers a relationship advantage which may contribute to the production of trust, acquisition of social resources, and reduction in transaction costs (Burt, 1992). Consequently, the different structural position of firms in the social network has a direct impact on their competitiveness. It has already been shown that Chinese entrepreneurs are actively expanding into structural holes in the external environment to achieve favourable resources (Yang, 2004). Furthermore, trade credit is a good reflection of the competitive advantage obtained from market competition, and can form an optimal foundation for transforming network advantages into business efficiency. As a debt contract based on a trust relationship, trade credit may result in differences in the parties' negotiation ability due to their network structural positions. One of the significant factors is the embeddedness of the network structure. Burt (1992) was first to propose the concept of "structural holes," noting that in some social networks, there are indirect or interrupted connections between some individuals, which seen from the overall network perspective, can be considered as holes in the structure. When there are such structural holes, any third party that can link the two disconnected parties has an information and control advantage, and so plays a vital role in the firms' competitive behaviour in the market. Unfortunately, however, few scholars have conducted crossover studies from the perspective of both structural holes and trade credit.[2] This paper explores this issue.

Organisations in the social network float in an environment formed by all kinds of relational networks, and resources are accessed mainly through specific and embedded individual networks. According to Jackson (2008), the measurement of social interaction can be modelled on the basis of specific actors in the social network; therefore, networks are constructed in this paper through the common board membership relations of influential

[2] From a sociological perspective, a social network consists of two parts that decide the main interaction, namely the network relationship and structure (Granovetter, 1992). The network relationship perspective does not distinguish particularly between strong and weak connections, but focuses on whether or not one exists. However, the network structure perspective, especially that focused on structural hole positions, distinguishes between types of relationship. More attention is paid to the bridge connection positions in organisations of different types for achieving information (if these are different for the two firms) and control advantages (if individuals linked by the intermediary agent require to connect, they must go through the intermediary). The embeddedness of the network structure created by such connections focuses on the strategic structural position of the individual, and stresses the functions of the intermediary and bridge. In particular, the structural hole is the type of network structure position that frequently occurs in the study of social networks. Granovetter (2005) also considers that in most cases, what is most important in terms of competition is not the quality of network relationships, but the positions of bridges between different networks. Zaheer and Bell (2005) find that the influence of company networks on performance is produced by the structural hole structure, rather than the immediate network relationships.

directors and senior managers, so as to illuminate the relationship between the network positions of firm structural holes and trade credit. Specifically, in this paper, the director network generated by the common service relationship is constructed using data from A-share listed companies from 2001 to 2011, and the network positions of the structural holes for different firms calculated using the network restraint coefficient. This enables the differences between the costs of acquiring and applying the trade credit of listed companies in different structural hole network positions to be compared. The empirical results show that firms with more structural holes can get more trade credit and enhance their competitiveness in the product market, as well as reducing their trade credit-cash sensitivity. This result remains unchanged after controlling for the endogeneity problem and the influence of network centrality. Additional analyses show the influence of structural holes on trade credit, which is more obvious in more competitive industry sectors and in regions with a higher degree of marketisation. Moreover, the role of structural holes in trade credit is mainly seen among larger firms, firms that have been listed for longer, those with a worse information environment, and those operating during a period of loose monetary policy.

This paper contributes to the literature in the following ways. Firstly, studies of trade credit to date have mainly been based on the perspective of the attributive characteristics of a single firm. This study is conducted from the perspective of firms' structural hole positions in a social network, and shows that these positions may strengthen the acquisition of trade credit and reduce the cost of applying it, while the hole also relies on market contracts to exercise its function. This paper accordingly extends the literature on trade credit. Secondly, crossover studies of social networks and corporate finance have become common in recent years (Engelberg *et al.*, 2012; Cai and Sevilir, 2012; Fracassi and Tate, 2012; Larcker *et al.*, 2013), but most are based on the perspective of network tie (if such exists); research on network structure and its links to organisation and strategy tend to use small samples so that the position of a firm may be more easily (although artificially) separated. This paper starts from the perspective of the structural embeddedness of a network, and draws on a large sample of listed companies in China. Differences in structural hole positions between firms are shown to have a large impact on corporate financial behaviour. In addition, the conclusions of this study have practical significance. During the downturn in capital markets and the macro-economy in recent years, trade credit is crucial for firms' operation whether it is seen as an alternative means of financing or as an approach to dealing with market competition. This paper shows that firms can gain trade credit by expanding their strategic positions in the social network, so as to capture opportunities for market competition.

The remainder of this paper is arranged as follows: Section II presents the literature review and research hypotheses; Section III the research design; Section IV reports the empirical analysis, and Section V sets out the conclusions.

II. Literature Review and Research Hypothesis

2.1 Social networks and trade credit

There are two perspectives from which to study social networks: their structure and the intensity of ties. Literature focusing on the structural perspective concentrates mainly on topics such as corporate innovation and entrepreneurship, strategy, and organisation. It has been shown that a firm's position in the network structure and management network affects its strategy and performance (Walker *et al.*, 1997), innovation and entrepreneurship (Rodan, 2010), market share (Baum *et al.*, 2005; Shipilov *et al.*, 2006), amount of patents (Ahuja, 2000), and knowledge transfer (Reagans and McEvily, 2003). Yang (2004) points out that in transition economies, especially China, entrepreneurs are actively developing their structural hole positions in the external environment to gain access to resources. Yao and Xi (2008) find that a firm will have more of an advantage in coping with changes in the industry when its senior managers have more structural holes in the consulting network. Qian *et al.* (2010) show that firms in network centres with more structural holes have an advantage in terms of innovation. Liu *et al.* (2011) measure the network positions of firms using the centrality and structural hole indexes, and show that different redundant resources are positively correlated with the degree of firms' diversification, but the regulatory role of network positions may be different due to the types of redundant resources. All these studies use small samples in order to artificially separate the network positions of firms more easily.

Research from the perspective of the intensity of network ties has become more popular in the field of corporate finance.[3] For instance, Fracassi and Tate (2012) define the external networks of company directors and chief executive officers (CEOs), and find that CEOs with greater power are more likely to appoint directors who are connected to their networks. Engelberg *et al.* (2012) find that if the senior executive of a bank has an alumni relationship with the senior executive of a company, the company may be able to obtain lower interest rates and demonstrate better performance. They suggest that the social network relationship can result in more information or better supervision. Larcker *et al.* (2013) show that a board of directors in a central network position can earn higher stock returns. Chen and Xie (2011, 2012), using data from Chinese capital markets, show that independent directors in central network positions can improve the company's investment efficiency and executive incentives. However, this literature, such as Fracassi and Tate (2012), Engelberg *et al.* (2012) and Larcker *et al.* (2013), attaches primary importance to the discussion of the existence and intensity of network relations (that is, exploring whether there are any network relationships, or measuring their intensity with reference to centrality). Some Chinese literature shows a similar trend (for instance, Chen and Xie, 2011)), while there has been a lack of studies on network structure. Moreover, no research to date explores

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[3] For a more detailed research summary please refer to Chen, Xie, and Huang (2012).

the impact of network structural hole positions on corporate finance behaviour, especially trade credit. However, even though less work has been done to examine accounting, corporate finance, and governance from the perspective of network position, this perspective, as a significant component of social networks, obviously cannot be neglected. Granovetter (2005) and Jackson (2008) stress the significant role of network structure position for firms' economic outcomes, including the corporate financial system. Mitchell (2005) identifies that the structural hole positions taken by CEOs play a significant role in the efficiency of corporate governance, and emphasises the importance of this element. Shaw *et al.* (2005) select the structural hole position, as a kind of the employee network, to discuss the influence of employee demission and social capital scattering on corporate performance. Zaheer and Bell (2005) also find that the influence of corporate network on performance is not generated directly through the network relation, but through the structural hole network structure. Therefore, this paper attempts to study the influence of social network on corporate financial behaviour from the relationship between firm structural hole positions and trade credit.

Current research on trade credit concentrates on exploring the theories of alternative financing and the buyer's market. According to the former, the offering and acquisition of trade credit by a firm is a kind of financing substitution for bank loans, while the latter (Fabbri and Menichini, 2010) proposes that it is mainly related to the quality of the buyer's client credit, with the suppliers willing to provide trade credit for certain clients in order to promote product sales. Yu and Pan (2010) prove the trade credit competition hypothesis for China's capital market, and show that private firms use it more than state-owned firms as a means of competing in the product market. Liu *et al.* (2009) find that different levels of trust between regions may result in various forms of contract signing, and there is also a great difference in the trade credit model. Lu and Yang (2011) find that in Chinese capital markets the substantial existence of trade credit during a period of loose monetary policy can be explained by the buyer's market theory, while under a tight monetary policy the alternative financing theory applies. Liu and Sheng (2011) find that under the existing bank credit system, there is still a certain degree of credit loan prejudice against nonstate-owned firms, while the trade credit system plays a significant supplementary role in the bank credit system. Wu *et al.* (2012) point out the asymmetric cost of using accounts payable and receivable, and find that financial development plays a significant role in the cost of using trade credit. In conclusion, there is a lack of literature on the acquisition and cost to firms of using trade credit from a network perspective. This paper examines both aspects using data from a large sample of listed companies.

2.2 Structural hole network position and acquisition of trade credit

The sociologist Ronald S. Burt defined the structural hole in the book *Structural Holes:*

The Social Structure of Competition in 1992. He considers that the social networks of organisations and individuals can be divided into two types: a structural network without holes, where any individuals is connected to other individuals directly, with no interrupted relations between any two people, and a structural network with holes, where some individuals are not directly connected to each other. If one takes an overview of the entire network, it can be seen that there are holes in the structure. Compared to a dense network without any holes, the actor in the central position in a network with sparse relationships may obtain more heterogeneous information, which will help him or her to gain a dominant position and other antecedent advantages. Structural holes not only confer advantages in terms of actors' acquisition of resources, but also have strategic benefits. Burt (1992) considers that the intensity of a connection is not necessarily related to the amount of social capital, and the key to achieving competitive advantage is to take up a significant structural position in the exchange of resources. Specifically, such an advantageous position consists of one where information and control benefits may be obtained.[4]

Differences in the strategic position of firms in a social network can be explained by the theory of structural holes. Figure 1 illustrates a network relationship diagram for five firms. The solid line represents a direct connection between directors, while the dashed line represents a lack of any connection. There are five participants, A, B, C, D, and E, in the network. There is no direct connection between B, C, D, and E, all are directly connected to A, so A holds a core strategic position in the network. In addition, the other four firms must all communicate through A, and as a result, A controls any cooperation between them. It can be seen that the structural hole is the gap between nonredundant contacts. As a result, contacts on each side of the hole have accumulated but not overlapping network gains, and the firm in the central position plays a crucial role. The theory of structural holes describes how social networks in competitive fields create opportunities for some actors and affect their relationships (Burt, 1992), and how more structural holes may help them to gain competitive advantages. Before measuring the network positions of structural holes, the direct relationship between firms is defined as follows: if the directors/senior executives of two different companies hold positions on each other's boards, the companies may have a direct connection.[5] In a firm network connected by directors, the members of each board can be seen as a clique, so there will be no direct connections between directors who do not hold any additional posts; instead, they may communicate indirectly through a linked

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4 Information benefits mean that the actor in a structural hole position may achieve and exchange heterogeneity information in various ways to act as an intermediary. Control benefits mean that such an actor may connect other, disconnected individuals and hold a core position in the mutual connection of other nodes in the network in order to achieve control over the flows of various crucial resources and their accompanying benefits.

5 Liu *et al.* (2011) construct the structural hole positions of interlocking directors, which are connected to the diversification of strategy. Xie and Chen (2012) construct a directors' network through their common board seat relationships.

director. In this way, the entire firm network is full of structural holes. In the circumstances, the network position of the structural hole is based on the firm's social network as formed by the interlinked directors.[6] Such network input, from the perspective of individuals, and network output, from the perspective of the organisation, is the general approach to studying social networks (see for example Jackson, 2008; Larcker *et al.*, 2013).

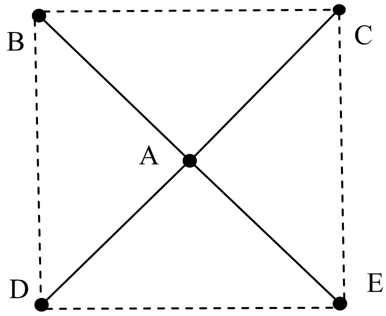

Figure 1 Map of Firms' Structural Hole Positions

As seen from the social network, the structural hole captures the indirect relationship between disconnected network members in order to realise information and control benefits. On that basis, social capital can be defined, since the structural hole between network members determines the potential for information and opportunities. In a firm network with a large number of structural holes, the bridge plays an intermediary role, and the nodes taking up a bridging role may connect separated subnetworks to communicate information. If a firm is located at the bridging node, it may occupy a position where it can seize information flow and business opportunities, making it easier to gain intermediary (control and information) benefits. The following section explains this in terms of the specific acquisition and application of trade credit.

Trade credit is a market resource configuration procedure achieved on the basis of an operational consensus reached between firms at a certain level of technological constraint and according to the corresponding market competition environment. It is a kind of unsecured debt contractual relation. The application of trade credit results in a time lag in the exchange of goods and cash during the transaction process; in other words, current income (expenditure) becomes the future cash inflow (outflow) of firms. If a firm can gain more trade credit in market competition, it holds the cash of other firms and thus gains a form of interest-free short-term financing. This is also a powerful reflection of its market competitiveness. Given the gaming of trade competitors in the market, the social network

[6] The network is mainly generated by the independent directors. In Chinese listed companies, the general manager/CEO usually sits on the board, so the director network also captures the decisions of senior management.

can reflect the relative negotiation status of both trading parties, such that the network can be measured according to game theory and related theories in the field of economic sociology (Jackson, 2008). The contractual relationship of trade credit therefore reflects the differences in the strategic negotiation positions of firms. If a certain firm is located at the central position of the structural hole, compared with other companies in the same industry, it may achieve more control and information benefits. The dominant position in negotiations it achieves as a result may help it gain favourable credit terms in the trading process. To be more specific, firstly, the information symmetry of both trade credit parties is crucial for a contractual relationship to be formed. Seen from perspective of the overall network, if the firm is at the central position of the structural hole, it takes up (through communication and exchanges with directors) a crucial point in the communication between firms in the network, and may therefore gain information benefits related to the trade credit contract. Such benefits may make it easier for the firm to establish trade credit arrangements with other firms at a lower cost.

Secondly, according to the buyer's market theory, the main reason why trade credit exists is related to the buyer's client credit, the power of which is reflected through the control benefits and bargaining power it obtains. A firm's structural hole network position allows it to control other firms in the supply chain, and trade credit is generated from this control in trading negotiations. If such a strategic control benefit is more apparent, the firm may have more bargaining power with suppliers, and hence may obtain more trade credit.

Thirdly, trade credit reflects a kind of implicit trust (Chen and Wang, 2010). For trade credit contracts without any material guarantees, reputation is a significant factor in establishing a contract. Moreover, the strategic position of the firm enables it to build up such trust and reputation (Chen and Xie, 2011). If it is in a structural hole position, it may gain the trust of other firms and be able to exert informal influence. In conclusion, therefore, the information, control, and trust benefits of being in a structural hole position can help a firm secure more trade credit.

Since the firm network studied in this paper has been generated on the basis of direct and indirect interlocking relationships between directors, in general terms, each firm may play three roles (supplier, producer, and client) to different degrees at the same time. In empirical studies, it is also difficult to distinguish between these roles or to determine if the director is the supplier, producer, or client in the same industrial chain depending on service condition. Therefore, in this paper, trade credit gained from a supplier will be inspected from the perspective of the producer, and the incremental role of the structural hole position will be studied from the perspective of a network of directors rather than an industrial chain. With the information, control, and trust benefits brought about by the structural hole network, even if the network relationship of directors fails to penetrate the supplier-client chain of the firm (i.e. the director network facilitates indirect supplier-client relations), there will be no effect on the function of the structural hole position in the director network in relation to trade credit. This is for the reasons which follow.

At first, the "symbol effect"[7] of network position may enable a firm's supplier to form an opinion. The operational and financial risk of client firms obtaining the information and control benefits from other types of network is lower, so the director network will reflect the overall information environment from the perspective of the company and product competitiveness, and offer guarantee for the trade credit provided by the firm (as the supplier).

Secondly, since the network transitivity effect in corporate finance may apply (Uzzi and Gillespie, 2002), the dynamics of a network of one type of trade partners when it increases trading with another type may lower demand for unique or exclusive resource partners to trade with the third party. Such a network transitivity effect also exists in the logic of this paper. The director network may not itself induce a direct supplier-client network to form, but the various reductions in trade costs brought about by other types of network may be transferred to supplier-client relations, increasing the trade credit provided by the supplier. Uzzi and Gillespie (2002) show that the embedded network of company and bank may form a unique governance mechanism which then encourages and protects the capability of banks, thereby further promoting trade between the company and trade credit suppliers.

Thirdly, and in contrast, since the structural hole position of the client can enable it to access all kinds of resources, if such a client firm breaches a trade credit contract and disrupts a stable credit relationship, the reputational damage may be transferred to different contracting parties through its core structural position. As well as losing trade credit, the firm will lose social capital, which may in itself have a huge impact. Consequently, due to the network transitivity effect, firms at structural hole positions have to adhere to their trade credit contracts. In other words, both the positive and negative impact of holding a core structural hole position will bring them more trade credit.

On that basis, the first research hypothesis is proposed:[8]

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7 Lin (2002) considers that the reputation conferred by membership of the social network has a symbolic effect. Even if the actors cannot apply or mobilise the resources embedded in their social network, they still have a great sense of such symbolism. This allows others to perceive their social capital, which may improve their social position or reputation. Kilduff and Krackhardt (1994) also show that if an individual is thought to have a famous friend in the organisation, his or her reputation may be promoted even if in reality they are not as effective as believed. This reflects the cognitive balance theory.

8 It should also be pointed out that social capital can be gained by two network mechanisms, namely network closure and structural position. Coleman (1990) considers that the strong connections in network closure may lead to standardisation and trust. If such logic takes a dominant position, it opposes the first hypothesis. However, it should also be emphasised that the generation of network closure logic relies on a strong connection network, and so it belongs to the origin of intragroup social capital. However, the networks between listed and up-/downstream companies have ultragroup characteristics; they are loose, informal, open, and their members are not closely connected. Therefore, the logic of structural holes based on weak connections is more applicable to this paper. Nevertheless, it should be pointed out that the logic of network closure, which requires verification from empirical results, may still exist.

H1a: The more structural holes in the director network of a firm, the more trade credit the firm will gain.

2.3 Network positions of structural holes and cost of using trade credit

The acquisition of trade credit in the market is a reflection of a firm's competitive position. The more trade credit the firm gains, the more of the supplier's capital it holds in the short term. However, when acquiring trade credit, a certain amount of expected cash should be set aside for repayment of the liability in the future, because the delayed repayment of trade credit carries costs. For instance, the possible cash discount may decrease; the firm may be punished for delayed repayment; there may be damage to credit reputation (i.e. lowered credit rating) accompanied by opportunity costs; and the supplier may increase the price of their products. In order to avoid possible delayed repayment costs and a decrease in cash discount, the firm will have to hold a certain amount of reserve cash. In fact, there are various kinds of friction, such as industrial adjustment, changes in macro-economic policy and clients' operational conditions, and so on, in the capital market, which may result in uncertainty of expected cash returns in future. These uncertainties impact future cash outflow (repayment). According to the cash holding motivation theory, firms hold additional cash for risk prevention and to offset trading costs (Lins *et al.*, 2010). In addition, some also hold cash to repay credit before the due date in order to enjoy a discount. The increase in cash holdings caused by the application of trade credit is called the use-cost of trade credit. Using trade credit may put pressure on the liquidity of firms, which may further result in an increase in trade credit-cash sensitivity (Wu *et al.*, 2012).

Similar to the logic of the structural hole position and acquisition of trade credit outlined above, the information and control benefits generated by structural hole network positions may enable trading parties to gain trust and lower the uncertainty of trading. Furthermore, if more trade credit is obtained, its cost is also reduced. Specifically, at first, the cost risk of trade credit is due to the fact that the debt contract is reached on the basis of trust. The conclusion of a contract generates not only a direct trading cost but also the risk costs of breach (Williamson, 1998; Fabbri and Menichini, 2010). From the perspective of trade credit acquisition and application, since the acquisition of trade credit imposes a liquidity cost, such trade credit reflects asymmetric and uncertain information. Holding a strategic position may allow a firm to lower the use-cost of trade credit resulting from uncertainty. The use-cost of trade credit reflects the trading cost during the trading process, and the trading network between suppliers and customers determines the market constraints for a firm. In a trading situation constrained by various kinds of embedded authority, the firm's network structural relationships may make trading more convenient, or may restrain negotiations. Moreover, firms at structural hole positions can take advantage of the control forces in the network to decrease trading costs. Furthermore, companies with more structural hole positions can also guarantee the application of trade credit by lowering the liquidity risk. More positions means that firms can achieve more external financing. Even if there is no need to achieve such financing at present, the potential fund reservoir may help to reduce cash holdings. Firms at structural hole positions can decrease their future liquidity expectations such that there is no need for more cash holdings. On that basis, the second hypothesis is proposed:

H1b: The more structural holes in the director network of a firm, the lower will be the sensitivity of trade credit-cash holding.

2.4 Network positions of structural holes, acquisition of trade credit, and application costs: Market-based contingency perspective

Podolny and Baron (1997) propose the contingency perspective of structural holes. They suggest that whether or not the structural hole position can be transformed into social capital relies on the specific network, namely the relationships between participants. In this paper, the network between firms and trade credit as defined actually belongs to a trading network, and reflects how the trading nature of firms influences understanding of their actions in the market (Jackson, 2008). Therefore, the more marketised the trading platform, the stronger the function of structural hole network position. The application of trade credit and the liquidity costs to a firm are closely related to the market. Since a contractual relationship between manufacturers and customers is naturally formed during the marketisation process (Peterson and Rajan, 1997), it can provide conditions for a firm to establish its strategic position and apply trade credit. The manifestation of such market factors can be analysed in terms of the degree of industrial competition and the level of regional marketisation.

Firstly, the function of a structural hole relies on the level of industrial competition. In a monopoly industry, a firm can take advantage of its status to achieve a dominant position in the industrial chain, thereby obtaining trade credit. At this point, the director-based network is a low-autonomy network in respect of the monopoly industry; that is to say, the impact on firm behaviour of the information and control benefits gained through the network of directors may decrease, so the firm relies less on the function of that network. In other words, a firm may achieve trade credit easily through its monopoly status, and so the function of structural hole position may not be evident. However, in industries where there is fierce competition, since one firm cannot achieve more than others through an inherent monopoly, the structural hole position based on the director network can bring information and control benefits related to business contracts. Therefore, the structural autonomy of the director network is much stronger, and the firm can naturally achieve more competitive advantage through the network as maintained by individuals. This demonstrates the role of the structural hole position more clearly.

In addition, according to the hypothesis of trade credit competition, trade credit can be a competitive approach in the market. When a supplier has numerous competitors, firms can easily find an alternative, so the acquisition of trade credit is more sensitive. Meanwhile, the firm's liquidity risk in such a market is also enhanced after gaining trade credit. Zhang and Wu (2012) find that there is an incidence relation between market competition and excessive cash holdings. At this point, the advantage of structural position in the social network can be reflected in the competitive market. In industries with high market competition, holding a structural hole position may enable a firm to gain more trade credit, and makes the strategy of trade credit-cash holding much more sensitive.

Secondly, the formation of structural hole network represents a firm's spontaneous behaviour in the market, and its trade credit policy is also the result of market trading. The higher the level of marketisation and development of a region, the greater the impact of structural hole position on trade credit. Coleman (1990) considers that the establishment of a standardisation and punishment system in network relations is based on whether or not the contract has been concluded in a reliable environment. When the level of marketisation of the region is high, there will be a good and reliable environment for the signing and execution of contracts between stakeholders (Chen and Wang, 2010). With such a background, trade credit behaviour based on the market trading network is much more marketised, which makes it more likely that a structural hole will confer obvious benefit. On that basis, another two hypotheses are proposed:

H2a: In industries with high market competition, holding a structural hole position has a greater impact on the acquisition and use-cost of trade credit.

H2b: In regions with a higher level of marketisation, holding a structural hole position has a greater impact on the acquisition and use-cost of trade credit.

III. Research Design

3.1 Research model and variable definition

In order to study the relationship between structural hole position and trade credit, the acquisition and use-cost of trade credit are considered at the same time, and the model is built as follows:

$$TC_{it} = \alpha_0 + \alpha_1 CI_{it} + \sum Controls_{it-1} + \varepsilon \tag{1}$$

$$CASH_{it} = \beta_0 + \beta_1 CI_{it} + \beta_2 CI_{it} \times TC_{it} + \beta_3 TC_{it} + \sum Controls_{it-1} + \delta \tag{2}$$

Model (1) is used to test the relationship between structural hole network position and the acquisition of trade credit, while model (2) is used to test the influence of hole position on the use-cost of trade credit (Wu *et al.*, 2012). Following Burt (1992) and Zaheer and Bell (2005), the following model is applied for the calculation of the structural hole:

$$C_{ij} = (p_{ij} + \sum_q p_{iq} p_{jq})^2 , \quad (3)$$

where i is a certain business entity in the network of overall listed companies; j stands for other firms in the network; and q is another business entity, namely $q \neq i, j$. P_{ij} equals the intensity of the direct connection from firm i to firm j (if a director holds posts in both firms i and j, the two companies are considered to have a direct connection), capturing the direct relational investment of firm i in firm j. $\sum_q p_{iq} p_{jq}$ equals the sum of the intensity of indirect connections in all paths through q from i to j, capturing the indirect relational investment of firm i in firm j. C_{ij} is the constraint of the relational investment required by the contact between firm i and firm j, namely the constraint index,[9] which effectively measures the deficiency of firm structural holes. The maximum value of the constraint index is 1; for convenience, we usually use the difference between 1 and the constraint index to measure the abundance of structural holes (Burt, 1992; Zaheer and Bell, 2005): $CI_i = 1 - C_{ij}$. The greater CI_i, the smaller the network constraint, and the more structural holes in the network. Therefore, in this paper, the *CI* index is applied to measure the abundance of a firm's structural holes.[10]

Four types of trade credit indexes (*TC*) are used. *TC1* = (accounts payable + notes payable)/total assets at the end of year t, considering that a firm obtaining the trade credit also offers it. Therefore, *TC2* considers the net value of trade credit, namely (accounts payable + notes payable – receivables – notes receivable) / total assets at the end of year t. Meanwhile, the offering of trade credit involves an industrial difference, so the adjusted *TC1_adj* and *TC2_adj* are applied for measurement, and in the subsample study, the comprehensive *TC2_adj* is the research variable. Referring to Wu *et al.* (2012), *CASH* is defined as monetary capital / (total assets – monetary capital) at the end of year t. It is predicted that α_1 in model (1) is positive, meaning that the stronger the structural hole network position of the firm, the more trade credit will be obtained. The interaction coefficient β_2 of model (2) is predicted to be negative, meaning that the stronger the structural hole network position, the weaker the positive correlation between trade credit and cash holdings. Following the literature on cash holdings (Lins *et al.*, 2010; Wu *et al.*,

9 Among numerous indexes for measuring structural holes, the network constraint index is the most widely used and has high generality. The higher the constraint index, the fewer the structural holes, and the more marginal the network position of an enterprise. Therefore, the constraint is usually negatively related to performance (Burt, 2004).

10 The calculation method of the structural hole index is set out in detail in the appendix.

2012), the main governance and basic corporate condition variables, such as firm size, leverage level, growth, investment, operating cash flow, and ultimate controller, are all controlled for. Meanwhile, the variable *POST* is set to control for the influence of the implementation of the *Property Law* in 2007 on trade credit financing (Wu *et al.*, 2012). According to the *Property Law* and the subsequent *Registration Method of the Pledge of Accounts Receivable*, banks can provide much more targeted receivables financial products for firms to use when pledging trade credit, which decreases the technical difficulties involved in recovering the receivables, reduces the uncertainty of future cash flows, and thus affects firms' trade credit behaviour. In 2007, new accounting standards were implemented by listed companies, essentially reforming nontradable shares. Therefore, the variable *POST* also controls for the possible impact of these aspects. In order to lower the mechanical correlation, control variables are processed with one lag phase. Detailed variable definitions are shown in Table 1. In the regression analysis, the degree of industrial competition (*HHI*) and the degree of marketisation (*MKT*) are distinguished, and then the function of the difference in the relationship between the structural hole network position and acquisition and use-cost of trade credit, under the contingency factor of marketisation, is analysed.

3.2 Sample and data

The sample is selected from A-share listed firms in the Chinese capital market between 2001 and 2011. After eliminating observations from the financial industry and firms with board of directors and other financial and governance data missing, 12,167 firm-year observations are used (different variables have different missing values, so the sample size entered into the regression in each model is not the same). To calculate the structural hole positions of firms, all board directors of the sample companies in each year are searched and this treated as the basic information set, as the network relationships are based on the directors. Then, each director is given a unique code. After clarifying and cleaning the database of directors in the listed companies, a director-director model matrix is constructed which depicts the relations between different directors. If directors i and j both work in at least one company, the value of matrix (i, j) is 1, and 0 otherwise. Afterwards, the large social network analysis program Pajek is used for calculating the network constraint index of the structural hole positions. In order to eliminate the impact of extreme values, 1% Winsorisation is conducted for the continuous variables. Meanwhile, a cluster adjustment is performed from the company perspective. SAS is used for the statistical and regression analyses.

Table 1 Variable Definitions

Name of variable	Symbol	Variable definitions
Network constraint index	*CI*	Structural hole measurement index, and the method is mentioned previously, calculated with Pajek
Trade credit	*TC1*	(Accounts payable + notes payable) / total assets at the end of year *t*
	TC1_adj	(Accounts payable + notes payable) / total assets at the end of year *t* after adjustment
	TC2	(accounts payable + notes payable – receivables – notes receivable) / total assets at the end of year *t*
	TC2_adj	(accounts payable + notes payable – receivables – notes receivable) / total assets at the end of year *t* after adjustment
Cash	*CASH*	Monetary capital / (total assets – monetary capital) at the end of year *t*
Firm size	*SIZE*	Natural logarithm of total assets at the end of year *t*-1
Leverage level	*LEV*	Total liabilities / total assets at the end of year *t*-1
Growth	*MB*	Market value / book value at the end of year *t*-1
Investment	*INV*	(fixed assets + construction in progress + intangible assets + long-term investment) / total assets at year *t*-1[11]
Operating cash flow	*OCF*	Net cash flow / total assets at year *t*-1
Ultimate controller	*SOE*	Dummy variable; if the ultimate controller of the firm is state-owned, it takes the value of 1, and 0 otherwise.
Dummy variable before and after the *Property Law* is implemented	*POST*	Dummy variable; if the year is after 2007, it takes the value of 1, and 0 otherwise.
Degree of Industrial competition	*HHI*	Herfindahl index dummy variable; if it is higher than the medium value of all industries, it takes the value of 1, and 0 otherwise.
Degree of marketisation	*MKT*	Dummy variable; if the marketisation index is higher than the annual medium value, it takes the value of 1, and 0 otherwise.
Industry / year	*IND/YEAR*	Following the industry classification standards of 2001 issued by the China Securities Regulatory Commission (CSRC), the manufacturing industry is classified with two codes, while the others are classified with one code. The sample interval is 11 years, and so there are 10 year dummy variables.

IV. Empirical Results

4.1 Descriptive statistics[12]

[11] After the new accounting standard was implemented in 2006, long-term investment is defined as (held-to-maturity investment + available-for-sale financial assets + net long-term equity investment).

[12] To save space, the related coefficient analysis is not provided, but is available upon request.

The descriptive statistics of the variables are shown in Table 2. The mean value of the network constraint coefficient is 0.273 (the median is 0.047), and the difference between the maximum and the minimum is 0.896, suggesting a huge difference in the abundance of structural holes between different companies. This provides a convenient setting for the study. The mean value of acquired trade credit (*TC1*) is 0.118, suggesting that accounts and notes payable take up 12% of the total assets, and the application of trade credit has become the main approach to market competition of the listed companies. *CASH* reaches 0.21 on average, suggesting that the percentage of cash holdings in the total assets of listed companies is also relatively large. How to manage this cash effectively turns out to be a significant problem for firms.

Table 2 Descriptive Statistics

Variable	OBS	Mean	Median	Max	Min	Std.
CI	12167	0.273	0.047	0.896	0.000	0.298
CASH	12163	0.207	0.142	1.716	0.006	0.227
TC1	12167	0.118	0.091	0.392	0.002	0.096
TC1_adj	12167	0.022	0.001	0.266	-0.111	0.084
TC2	12167	-0.010	-0.004	0.235	-0.360	0.113
TC2_adj	12167	0.003	0.002	0.240	-0.286	0.103
SIZE	12164	21.302	21.204	24.214	19.126	1.075
LEV	12164	0.516	0.511	1.172	0.074	0.218
MB	12096	1.587	1.276	5.049	0.855	0.867
INV	12156	0.451	0.445	0.860	0.033	0.209
OCF	12164	0.049	0.048	0.237	-0.159	0.079
SOE	12140	0.644	1.000	1.000	0.000	0.479
POST	12167	0.379	0.000	1.000	0.000	0.485
HHI	12167	0.257	0.000	1.000	0.000	0.437
MKT	12167	0.728	1.000	1.000	0.000	0.445

Figure 2 shows the comparison of trade credit acquisition of firms with different numbers of structural holes. If the firms are divided into two groups according to their *CI* score (the results of using the median as the standard are similar to those using the average value), it can be seen that firms with more structural holes obtain more trade credit than those with sparse structural holes. This trend provides preliminary support for H1a.

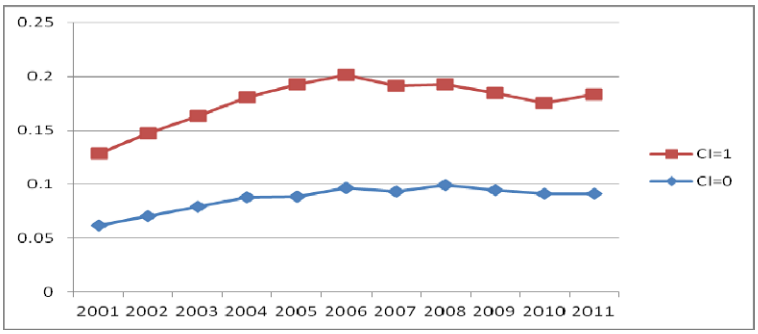

Figure 2 Trade Credit Trends for Different Numbers of Structural Holes

4.2 Regression analysis

The regression results of models (1) and (2) are shown in Table 3, in which the first four columns show the relationship between the degree of abundance of structural holes and the acquisition of trade credit. When the dependent variables are *TC1* and *TC1_adj*, *CI* and *TC* are significantly and positively related at the 5% level. If only the net amount after the acquisition and providing of trade credit is considered (*TC2* and *TC2_adj*), the coefficient of *CI* is close to significance. Since *TC2_adj* is equal to (accounts payable + notes payable – receivables – notes receivable) divided by total assets at the end of year *t* adjusted by the industry median, and considers the net trade credit and industrial adjustment, it is a comparatively comprehensive index in this context; therefore, *TC2_adj* is used as the main index for the subsamples in this study. Columns 5 to 8 show the relationship between the abundance of structural holes and the use-cost of trade credit. No matter which of the four *TC* variables is used, the coefficient of *CI* is significant and negative at the 5% and 1% levels. Columns 9 to 12 show the results of using cash holdings as the dependent variable (*CASH_adj*) after the industrial adjustment.[13] The cross-term coefficient is not significant when the independent variable is *TC1_adj*, but otherwise, the remaining three cross-term coefficients are all significantly negative at the 5% and 1% level. The results presented in Columns 5 to 12 show that a higher degree of abundance of structural hole positions markedly reduces the sensitivity of trade credit-cash holdings. As the results in Table 3 demonstrate, H1a and H1b are verified in general terms.

The relationship between the network positions of structural holes and trade credit is further studied from the perspective of the contingency of marketisation agent, as shown in Tables 4 and 5.[14] Table 4 shows the results of distinguishing between different degrees of product market competition. The first two columns show the results of the degree of abundance of structural holes and acquisition of trade credit after differentiating *HHI*; when *HHI* = 0, the coefficient of *CI* is not significant, but when *HHI* = 1, the *CI* coefficient is positive and significant (coefficient 0.023, at the 1% level), and the difference between the two is 0.019. The Chow test further illustrates that the difference between the two is significant at the 5% level, suggesting that when product market competition is severe, holding a structural hole position may enhance the acquisition of trade credit. The last two columns show the results of the structural hole position and use-cost of trade credit after differentiating *HHI*. When *HHI* = 0, the coefficient of *CI***TC* is -0.173, but when *HHI* = 1, the coefficient is -0.225, and the coefficient difference is -0.092. According to the Chow test, F is significant at the 1% level, suggesting that when product market competition is fierce, holding a structural hole position may save the use-cost of trade credit. Thus H2a is verified.

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[13] The suggestions of the referees are noted here with thanks.

[14] To save space, only the results of *TC* = *TC2_adj* are shown, but the results of other variables are similar and are available upon request.

Table 3 Relationship between Structural Hole Position and Trade Credit

	1	2	3	4	5	6	7	8	9	10	11	12
	Dependent variable: *TC*				Dependent variable: *CASH*				Dependent variable: *CASH_adj*			
	TC1	*TC1_adj*	*TC2*	*TC2_adj*	*TC1*	*TC1_adj*	*TC2*	*TC2_adj*	*TC1*	*TC1_adj*	*TC2*	*TC2_adj*
TC					0.021	0.014	0.398***	0.406***	-0.021	0.0093	0.39***	0.40***
					(0.39)	(0.25)	(11.59)	(11.72)	(-0.38)	(0.85)	(11.45)	(11.79)
*CI*TC*					-0.216**	-0.258**	-0.187***	-0.187***	-0.20**	-0.013	-0.18***	-0.18***
					(-2.39)	(-2.53)	(-2.81)	(-2.90)	(-2.27)	(-0.23)	(-2.72)	(-2.88)
CI	0.006**	0.006**	0.003	0.003	0.028*	0.008	-0.001	0.001	0.028*	-0.25**	-0.0000012	0.0028
	(2.38)	(2.37)	(1.60)	(1.51)	(1.79)	(0.73)	(-0.14)	(0.14)	(1.81)	(-2.47)	(-0.00)	(0.27)
SIZE	0.005***	0.005***	0.015***	0.015***	-0.006	-0.006	-0.012***	-0.012***	-0.0064	-0.0063	-0.012***	-0.012***
	(5.97)	(6.33)	(7.15)	(7.16)	(-1.56)	(-1.52)	(-2.91)	(-2.93)	(-1.58)	(-1.55)	(-2.93)	(-2.97)
LEV	0.128***	0.125***	0.074***	0.076***	-0.203***	-0.203***	-0.242***	-0.243***	-0.20***	-0.20***	-0.24***	-0.24***
	(37.06)	(36.58)	(7.72)	(8.18)	(-9.17)	(-9.20)	(-11.21)	(-11.27)	(-9.18)	(-9.20)	(-11.22)	(-11.30)
MB	-0.008***	-0.007***	-0.003	-0.003	0.026***	0.026***	0.028***	0.028***	0.025***	0.025***	0.026***	0.026***
	(-6.99)	(-5.98)	(-1.40)	(-1.15)	(4.71)	(4.72)	(4.98)	(4.91)	(4.39)	(4.40)	(4.65)	(4.59)
INV	-0.100***	-0.101***	0.042***	0.042***	-0.412***	-0.413***	-0.418***	-0.418***	-0.41***	-0.41***	-0.41***	-0.41***
	(-24.09)	(-24.51)	(4.06)	(4.10)	(-17.08)	(-17.06)	(-18.23)	(-18.25)	(-16.83)	(-16.82)	(-18.04)	(-18.07)
OCF	0.077***	0.079***	0.152***	0.146***	0.474***	0.475***	0.415***	0.417***	0.46***	0.46***	0.40***	0.40***
	(7.95)	(8.29)	(9.48)	(9.18)	(10.40)	(10.40)	(9.48)	(9.49)	(10.10)	(10.11)	(9.20)	(9.19)
SOE	0.010***	0.010***	0.008*	0.008*	0.019**	0.019**	0.016**	0.015**	0.020**	0.020**	0.016**	0.016**
	(6.37)	(6.34)	(1.88)	(1.88)	(2.43)	(2.42)	(2.09)	(2.08)	(2.54)	(2.53)	(2.21)	(2.19)
POST	0.014***	0.002	0.044***	0.016***	0.058***	0.057***	0.005	0.016	0.023**	0.022**	0.015	0.030***
	(3.92)	(0.61)	(8.51)	(3.16)	(5.80)	(5.74)	(0.51)	(1.47)	(2.17)	(2.05)	(1.59)	(3.08)
CONS	-0.053***	-0.100***	-0.425***	-0.386***	0.551***	0.551***	0.709***	0.699***	0.38***	0.38***	0.54***	0.53***
	(-2.80)	(-5.41)	(-9.16)	(-8.44)	(5.82)	(5.81)	(7.38)	(7.30)	(4.06)	(4.04)	(5.65)	(5.58)
YEAR/IND	√	√	√	√	√	√	√	√	√	√	√	√
R-sqr	0.338	0.160	0.218	0.096	0.224	0.224	0.246	0.246	0.179	0.179	0.203	0.203
F-Value	175.98	65.61	38.18	13.10	20.15	20.22	20.61	20.69	16.14	16.16	18.53	18.88
Obs.	12103	12103	12064	12064	12101	12101	12062	12062	12100	12100	12061	12061

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

The results of marketisation are shown in Table 5. Similar to Table 4, when the dependent variable is *TC* and *MKT* = 0, the coefficient of *CI* is not significant, but when *MKT* = 1, the coefficient of *CI* is positive and significant at the 10% level. According to the Chow test, the difference (0.012) is significant at the 1% level, suggesting that the higher the marketisation level is, the stronger the function of structural hole network position in the acquisition of trade credit. When the dependent variable is *CASH* and *MKT* = 0, the coefficient of *CI*TC* is not significant, but when *MKT* = 1, the coefficient of *CI*TC* is negative and significant at the 1% level (coefficient -0.205). The Chow test shows that the difference (-0.149) is significant at the 1% level, suggesting that in regions with a high degree of marketisation, the network position of the structural hole may enable more savings in the use-cost of trade credit. H2b is accordingly verified.

Table 4 Product Market Competition, Structural Hole Position, and Trade Credit

	Dependent variable: *TC2_adj*			Dependent variable: *CASH*		
	HHI = 0	*HHI* = 1	Chow-F	*HHI* = 0	*HHI* = 1	Chow-F
TC				0.394***	0.430***	
				(15.35)	(7.98)	
*CI*TC*				-0.173***	-0.255**	-0.082***
				(-3.04)	(-2.11)	(4.24)
CI	0.004	0.023***	0.019**	-0.005	0.026*	
	(1.07)	(3.80)	(2.59)	(-0.73)	(1.86)	
SIZE	0.019***	0.006***		-0.009***	-0.015***	
	(14.74)	(3.42)		(-3.65)	(-3.57)	
LEV	0.076***	0.071***		-0.223***	-0.285***	
	(14.48)	(9.16)		(-22.33)	(-15.56)	
MB	-0.003**	-0.000		0.029***	0.029***	
	(-2.03)	(-0.00)		(8.93)	(4.51)	
INV	0.051***	0.021**		-0.393***	-0.505***	
	(8.19)	(2.16)		(-33.55)	(-22.01)	
OCF	0.156***	0.113***		0.387***	0.480***	
	(10.86)	(5.00)		(14.17)	(9.07)	
SOE	0.008***	0.003		0.015***	0.014	
	(3.61)	(0.74)		(3.45)	(1.54)	
POST	0.013**	0.017*		-0.002	0.067***	
	(2.39)	(1.91)		(-0.16)	(3.43)	
CONS	-0.470***	-0.194***		0.590***	0.941***	
	(-16.42)	(-4.68)		(10.74)	(9.71)	
YEAR/IND	√	√		√	√	
R-sqr	0.109	0.076		0.221	0.325	
F-Value	39.20	9.00		84.75	49.09	
Obs.	8977	3087		8976	3086	

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

Table 5 Marketisation, Structural Hole Position, and Trade Credit

	Dependent variable: *TC2_adj*			Dependent variable: *CASH*		
	MKT = 0	*MKT* = 1	Chow-F	*MKT* = 0	*MKT* = 1	Chow-F
TC				0.346***	0.411***	
				(6.52)	(9.38)	
*CI*TC*				-0.056	-0.205***	-0.149***
				(-0.52)	(-2.64)	(4.75)
CI	0.010	0.022*	0.012***	0.007	-0.007	
	(0.94)	(1.77)	(4.12)	(0.54)	(-0.54)	
SIZE	0.020***	0.013***		0.000	-0.017***	
	(4.87)	(5.42)		(0.04)	(-3.53)	
LEV	0.059***	0.081***		-0.188***	-0.265***	
	(3.42)	(7.56)		(-6.04)	(-9.80)	
MB	0.005	-0.006**		0.030**	0.028***	
	(1.21)	(-2.00)		(2.26)	(4.67)	
INV	0.056***	0.038***		-0.333***	-0.442***	
	(2.94)	(3.23)		(-9.93)	(-16.09)	
OCF	0.131***	0.147***		0.371***	0.427***	
	(4.24)	(8.10)		(4.80)	(8.12)	
SOE	0.002	0.011**		0.013	0.019**	
	(0.24)	(2.33)		(1.02)	(2.11)	
POST	0.009	0.013***		0.031	0.061***	
	(0.87)	(2.81)		(1.64)	(5.41)	
CONS	-0.482***	-0.346***		0.363*	0.816***	
	(-5.48)	(-6.57)		(1.83)	(7.45)	
YEAR/IND	√	√		√	√	
R-sqr	0.104	0.102		0.220	0.260	
F-Value	6.32	9.82		10.59	15.93	
Obs.	3282	8782		3281	8781	

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

4.3 Robustness testing

A series of robustness tests are conducted to check these results as follows.

1. Trade credit policies include the acquisition and provision of trade credit. The acquisition of trade credit and net acquisition are considered in the regression results at the same time. In the robustness test, *TC3* ((accounts receivable + notes receivable)/ total assets) and its adjusted value (*TC3_adj*) are applied to measure the proxy variable of trade credit provided at the firm's initiative (Wu *et al.*, 2012). It is found that the more structural holes in the firm's network, the more trade credit is provided by the firm, and that this strengthens its advantage in market competition. The results of *TC3_adj* are shown in the first and second columns of Table 6. To save space, the results of *TC3* are not reported, but they are similar to those of *TC3_adj*, and are consistent with the main results. The subsample of *TC1_adj* (divided by the degree of product market competition and the degree of regional marketisation) is also studied. It is found that the *CI* index is not significant in the trade

credit acquisition model, but all other results are significant. In addition, since trade credit is an alternative to bank credit to some extent, if a firm with more structural holes obtains more capital through trade credit, it will borrow less from banks. On that basis, (Accounts payable + notes payable)/total liabilities is taken as the alternative variable for trade credit. According to the unreported results, the outcome is basically the same.

2. The following tests of the possible problem of endogeneity are also conducted:[15]

(1) Control variables in the main regression result are processed with a one-period lag. In fact, if all variables are taken at time *t*, the results are the same. As shown by the third and fourth columns of Table 6, when the dependent variable is *TC2*, the *CI* coefficient is not significant, but when it is *TC2_adj*, the *CI* coefficient is positive and significant at the 10% level. When the dependent variable is *CASH*, the *CI*TC* coefficient is significant and negative at the 1% level, supporting H1a and H1b.

(2) The fixed effect model test is conducted from the perspective of the company (*TC2_adj* takes place of the variable *TC*), giving results similar to those in the last two columns of Table 6.

(3) By referring to the method of solving the endogeneity problem reported by Larcker *et al.* (2013), a further test is conducted as follows. In order to eliminate the condition that good companies attract directors with more network relationships and thus achieve more trade credit, an analysis is conducted to identify the influence of directors' relationships. Larcker *et al.* (2013) control for basic characteristic variables from the perspective of the company, such as performance, leverage level, growth, and firm size. On that basis, some corporate governance variables, including the ultimate controller, scale of board of directors, proportion of independent directors, and duality, are further controlled for, because it is considered that the current characteristics of the board of directors will influence the firm's future appointment decisions. Given the above variables, *CI* at year *t*+1 is taken as the dependent variable, and the influencing factor model of structural hole position examined. The results are shown in Table 7, which indicates that the coefficients of trade credit (*TC*) and *CI* for the previous period are not significant. This suggests that the results are not due to the fact that good companies can provide more trade credit and hire directors with larger networks. In addition, the coefficients of *ROA* and *CI* are significantly negative, suggesting that poorly performing companies are more willing to hire directors with large networks.

Although this type of study cannot acquire exogenous variables in the strict sense, it can limit the analysis to companies whose boards of directors have not changed from year *t* to year *t*+1. Changes in the structural holes of the director networks of such companies mainly come about as a result of changes in the directors of other companies in the network

[15] As pointed out by Larcker *et al.* (2013), this kind of study cannot eliminate all possible cause and effect, and the influence of endogeneity can only be reduced by several technical methods.

Table 6 Robustness Tests (1)

	1	2	3	4	5	6
	TC3_adj	*TC3_adj*	Same period	Same period	Fixed effect model	
TC		0.045		0.503***		0.291***
		(0.88)		(22.79)		(11.61)
*CI*TC*		-0.176**		-0.227***		-0.150***
		(-2.05)		(-4.49)		(-3.06)
CI	0.009***	0.006	0.003*	-0.003	0.001	0.013*
	(2.85)	(0.54)	(1.73)	(-0.41)	(0.39)	(1.80)
SIZE	0.011***	-0.007	0.017***	-0.019***	-0.018***	-0.040***
	(10.90)	(-1.61)	(17.47)	(-9.32)	(-10.16)	(-10.01)
LEV	0.173***	-0.213***	0.073***	-0.335***	0.061***	-0.102***
	(42.20)	(-9.53)	(18.33)	(-40.27)	(10.97)	(-8.41)
MB	-0.007***	0.027***	-0.001	0.015***	-0.001	0.020***
	(-5.46)	(4.77)	(-0.40)	(5.57)	(-0.80)	(6.76)
INV	-0.187***	-0.405***	0.052***	-0.604***	0.021***	-0.340***
	(-37.99)	(-16.29)	(10.79)	(-60.45)	(3.46)	(-25.57)
OCF	0.176***	0.468***	0.189***	0.544***	0.065***	0.248***
	(15.44)	(10.32)	(16.77)	(23.24)	(6.51)	(11.37)
SOE	0.013***	0.018**	0.005**	0.002	-0.003	0.021***
	(6.77)	(2.30)	(2.57)	(0.43)	(-1.15)	(3.16)
POST	-0.015***	0.021**	0.022***	-0.006	0.026***	0.057***
	(-3.74)	(1.98)	(5.03)	(-0.64)	(8.09)	(7.96)
CONS	-0.211***	0.557***	-0.443***	1.031***	0.341***	1.183***
	(-9.46)	(5.90)	(-20.31)	(22.72)	(8.77)	(13.86)
YEAR/IND	√	√	√	√	√	√
R-sqr	0.236	0.222	0.111	0.354	0.061	0.136
F-Value	106.63	19.52	47.26	196.92	42.98	91.72
Obs.	12098	12096	13681	13678	12064	12062

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

Table 7 Robustness Tests (2)

	Dependent variable: CI_{t+1}
TC	0.024
	(0.92)
ROA	-0.000***
	(-9.18)
SIZE	0.001
	(0.40)
LEV	-0.077***
	(-6.24)
MB	-0.031***
	(-9.69)
SOE	0.029***
	(4.91)
BOARD	0.023***
	(16.62)
OUT	0.129***
	(5.19)
DUAL	-0.022***
	(-2.80)
CONS	0.093
	(1.46)
YEAR/IND	√
R-sqr	0.060
F-Value	30.35
Obs.	11976

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

(Larcker *et al.*, 2013). Therefore, such changes are not endogenous selections caused by a company's decisions or changes in its own board. Moreover, independent directors are the main forces in the formation of director networks (Xie and Chen, 2012). Two kinds of samples are selected separately, one with independent directors without changes and another of all directors without changes, to reduce the endogeneity problem. The results in Table 8 are based on these two subsamples. Meanwhile, if the change model (first four columns) and the level model (last four columns) are used, the change model in particular has no endogeneity influence. The results in the first four columns show that changes in the structural hole network position are significantly correlated with changes in trade credit-cash holdings, but not with the acquisition of trade credit. As the results in the last four columns show, except for the sample of all directors without changes, in which changes in structural hole position are nonsignificantly correlated with the acquisition of trade credit, the results are all similar to the main findings.

3. In order to investigate the difference in the effect of the acquisition and application of trade credit between the network centrality index (which mainly measures the relational characteristics of the network) and the structural hole index (which mainly measures its structural embedded characteristics), the comprehensive index *Cen*[16] is used to calculate the centrality, intermediary centrality, proximity centrality, and eigenvector centrality of the firm's director network on the basis of interlocking directors (consistent with the director network as defined in this paper). It does so by referring to the network centrality indexes introduced by Freeman (1979), Wasserman and Faust (1994), and Larcker *et al.* (2013), and the definitions of Xie and Chen (2012). The analyses are conducted as follows. Firstly, it is found from the analysis of the correlated coefficient of the network centrality and structural hole indexes that the Pearson coefficient of *Cen* and *CI* is 0.52 and the related Spearman coefficient is 0.54, suggesting that the two have little correlation. Secondly, when *Cen* is put into the model as a control variable, it is nonsignificant for both the trade credit acquisition and application models, and has little impact on *CI*. This is shown by the results in the first two columns of Table 9 (the t-values of *Cen* in the two models are -0.24 and 1.41, respectively). Thirdly, if *Cen* replaces *CI* in the model, the coefficient of trade credit acquisition is not significant (t = -0.04). When the dependent variable is *CASH*, the coefficient of *Cen*TC* is significantly positive (t = 1.82), as shown by the results in the last two columns of Table 9. These three tests show that from the empirical perspective, there is a difference between structural hole index and centrality. The influence of structural hole index on trade credit is stronger than that of centrality, which is similar to the result found by Zaheer and Bell (2005). Moreover, this also highlights the function of structural hole

[16] Please see Xie and Chen (2012) for the detailed method of calculation.

Table 8 Robustness Tests (3)

	1		2		3		4	
	All directors unchanged sample		Independent directors unchanged sample		All directors unchanged sample		Independent directors unchanged sample	
Dependent variable	*⊿TC*	*⊿CASH*	*⊿TC*	*⊿CASH*	*TC*	*CASH*	*TC*	*CASH*
⊿CI	-0.003	0.005	0.000	0.001				
	(-0.46)	(0.34)	(0.01)	(0.13)				
⊿TC		0.253***		0.246***				
		(5.57)		(7.83)				
⊿CI⊿TC*		-0.162*		-0.112*				
		(-1.79)		(-1.81)				
CI					0.001	0.000	0.010**	0.004
					(0.15)	(0.02)	(2.05)	(0.46)
TC						0.415***		0.380***
						(8.44)		(10.60)
*CI*TC*						-0.179*		-0.152*
						(-1.69)		(-1.96)
SIZE	-0.003**	-0.007**	-0.003***	-0.006**	0.014***	-0.010**	0.015***	-0.010***
	(-2.19)	(-2.19)	(-2.85)	(-2.41)	(7.02)	(-2.46)	(9.95)	(-3.28)
LEV	-0.005	0.071***	0.002	0.059***	0.114***	-0.220***	0.119***	-0.215***
	(-0.81)	(4.91)	(0.51)	(5.77)	(13.12)	(-11.68)	(18.53)	(-16.36)
MB	0.002	0.007*	0.000	0.005*	-0.002	0.033***	-0.005**	0.031***
	(1.00)	(1.80)	(0.12)	(1.69)	(-0.79)	(6.04)	(-2.42)	(7.62)
INV	-0.001	0.112***	-0.008	0.112***	0.036***	-0.415***	0.010	-0.389***
	(-0.09)	(6.65)	(-1.50)	(9.11)	(3.61)	(-19.56)	(1.57)	(-25.43)
OCF	-0.062***	-0.089**	-0.051***	-0.096***	0.128***	0.478***	0.155***	0.425***
	(-4.01)	(-2.26)	(-4.26)	(-3.35)	(5.39)	(9.49)	(8.59)	(11.91)
SOE	0.002	0.008	0.003*	0.004	0.002	0.038***	0.004	0.023***
	(0.60)	(1.32)	(1.74)	(0.90)	(0.62)	(4.73)	(1.38)	(3.89)
POST	-0.003	0.015**	-0.002	0.016***	0.031**	0.017	0.039***	0.025
	(-0.94)	(2.09)	(-1.02)	(3.08)	(2.48)	(0.66)	(11.14)	(1.28)
CONS	0.066**	0.039	0.063***	0.027	-0.395***	0.607***	-0.403***	0.624***
	(2.39)	(0.56)	(2.97)	(0.53)	(-8.69)	(6.25)	(-12.65)	(8.98)
YEAR/IND	√	√	√	√	√	√	√	√
R-sqr	0.014	0.045	0.009	0.039	0.118	0.243	0.130	0.234
F-Value	1.68	5.11	1.98	8.12	11.63	26.46	104.70	47.02
Obs.	3149	3147	5848	5846	2998	2998	5592	5592

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

Table 9 Comparison of Structural Hole and Network Centrality Measures

	(1)	(2)	(3)	(4)
Dependent Variable	*TC2_adj*	*CASH*	*TC2_adj*	*CASH*
TC		0.41***		0.33***
		(11.73)		(11.19)
Cen	-0.00019	0.0024	-0.000033	0.0018
	(-0.24)	(1.41)	(-0.04)	(1.22)
CI	0.0034*	-0.0061		
	(1.69)	(-0.53)		
*CI*TC*		-0.19***		
		(-2.93)		
*Cen*TC*				0.017*
				(1.82)
SIZE	0.015***	-0.013***	0.015***	-0.015***
	(7.07)	(-3.13)	(7.28)	(-3.50)
LEV	0.075***	-0.24***	0.077***	-0.25***
	(8.11)	(-11.26)	(8.52)	(-11.94)
MB	-0.0025	0.028***	-0.0026	0.027***
	(-1.02)	(4.84)	(-1.08)	(4.74)
INV	0.042***	-0.42***	0.042***	-0.44***
	(4.06)	(-18.28)	(4.17)	(-18.81)
OCF	0.15***	0.41***	0.15***	0.43***
	(9.13)	(9.41)	(9.42)	(10.06)
SOE	0.0074*	0.015**	0.0080**	0.013*
	(1.84)	(2.03)	(2.03)	(1.73)
POST	0.013***	0.013	0.014***	0.028***
	(3.35)	(1.24)	(3.08)	(2.88)
CONS	-0.39***	0.72***	-0.39***	0.77***
	(-8.45)	(7.45)	(-8.74)	(7.89)
YEAR/IND	√	√	√	√
R-sqr	0.092	0.243	0.093	0.257
F-Value	14.2	23.3	18.5	22.1
Obs.	12032	12030	12521	12495

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

position on trade credit.[17]

4. This paper concludes that the network relationship of the structural hole impacts trade credit, which leads to another question: in industries with a typical trade credit chain where companies' networks are formed by directors from multiple sectors, are the results still valid? This is explored in terms of three aspects.

[17] If the logic of this paper is reflected to a higher degree as a closed network logic, the centrality index (which mainly measures the intensity of a closed network) may be more evident. However, according to the results in Table 9, the centrality index of the network is not significant, which further illustrates that the logic of trade credit is mainly based on the structural hole position rather than the nonclosed network. Meanwhile, the follow-up study shows that the function of structural hole position is mainly found in companies with a poor information environment which are operating during a period of loose monetary policy, which also verifies the conclusion.

(1) Since the main logic of the analysis is based on the information and control benefits gained from holding a structural hole position in a director network, such benefits should also be observed in a director network sample generated by independent directors from different industries. In order to explore further the immediate agents of the network connection, namely the interlocking directors, and to see if the same results can be achieved for different industries, two types of subsamples of multi-industry directors are selected separately. If any director holds a post in another company in a different industry, *INTERIND* = 1; if all independent directors are not in the same industry as the company, then *INTERINDALL* = 1. The second sample range is strictly limited. The results for the two subsamples show that the conclusion still holds, as shown by the first four columns in Table 10. The first and third columns in Table 10 indicate that *CI* is positive and significant at the 10% level, while the second and fourth columns indicate that *CI**TC* is negative and significant at the 1% level (the unreported results show that the results of two subsample groups of *INTERIND* = 0 and *INTERINDALL* = 0 are the same. Company samples for interlocking directors (sponsors of the structural hole positions) are also tested, and the results remain the same).

(2) The factor implied in trade credit is different from the relationship between the up- and downstream industries, but studies of trade credit based on large datasets cannot identify the two contracting companies. Gong and Mao (2007) find that resource industries in the upstream of the value chain and sales industries in the downstream have some crucial resources; meanwhile, firms in these industries seldom provide trade credit, and they find it easy to achieve a net trade credit balance. In addition, since the characteristics of the up- and downstream industrial chains are relatively clear in the manufacturing industry, companies from the manufacturing, resource, and retail industries (*INDALL*=1) are selected for further subsample study. The results are shown in the fifth and sixth columns of Table 10 (in unreported results, all three samples are also tested, and the results for the manufacturing and retail industries are significant).

(3) The integration of all the independent directors from different industries (*INTERINDALL*=1) and the three subdivided industry samples (*INDALL*=1) is performed. The results are shown in the last two columns of Table 10, in which CI is positive and significant at the 10% level, while *CI*TC* is negative and significant at the 10% level. These tests further show, from the empirical subsample perspective, that structural hole position affects trade credit.

5. In addition, the following robustness tests are also conducted (results unreported).

(1) Trade credit variables may include business between the company and related parties. In order to decrease the influence of such behaviour on the results, three types of transactions with related companies that may impact the two sample groups of trade credit

Table 10 Results by Industry and Specific Directors

	INTERIND=1	*INTERIND*=1	*INTERINDALL*=1	*INTERINDALL*=1	*INDALL*=1	*INDALL*=1	*INTERINDALL*=1 & *INDALL*=1	*INTERINDALL*=1 & *INDALL*=1
Dependent Variable	*TC2_adj*	*CASH*	*TC2_adj*	*CASH*	*TC2_adj*	*CASH*	*TC2_adj*	*CASH*
TC		0.44***		0.45***		0.42***		0.44***
		(14.22)		(12.71)		(14.68)		(10.01)
*CI*TC*		-0.23***		-0.21***		-0.21***		-0.16*
		(-3.71)		(-2.76)		(-3.17)		(-1.88)
CI	0.0067*	0.0047	0.0091*	0.0078	0.0037*	0.0053	0.0051*	0.017
	(1.83)	(0.57)	(1.87)	(0.78)	(1.75)	(0.64)	(1.73)	(1.32)
SIZE	0.015***	-0.013***	0.016***	-0.016***	0.015***	-0.0064**	0.017***	-0.0073*
	(11.93)	(-4.99)	(10.34)	(-5.00)	(10.69)	(-2.38)	(7.81)	(-1.81)
LEV	0.078***	-0.25***	0.080***	-0.26***	0.10***	-0.22***	0.095***	-0.25***
	(14.50)	(-23.53)	(12.78)	(-19.90)	(16.36)	(-18.61)	(10.33)	(-14.43)
MB	-0.0024	0.025***	0.00056	0.027***	-0.0037*	0.027***	0.0024	0.024***
	(-1.34)	(7.16)	(0.28)	(6.50)	(-1.80)	(7.20)	(0.85)	(4.50)
INV	0.043***	-0.42***	0.047***	-0.45***	0.025***	-0.45***	0.050***	-0.45***
	(6.71)	(-33.58)	(6.33)	(-29.43)	(3.53)	(-34.73)	(4.79)	(-22.95)
OCF	0.14***	0.41***	0.13***	0.40***	0.17***	0.47***	0.13***	0.41***
	(9.22)	(13.93)	(7.51)	(11.09)	(10.01)	(14.55)	(5.19)	(8.36)
SOE	0.0084***	0.011**	0.010***	0.014**	0.012***	0.0046	0.016***	-0.0073
	(3.42)	(2.21)	(3.51)	(2.37)	(4.22)	(0.90)	(3.98)	(-0.95)
POST	0.0082	0.026**	0.0086	0.055***	0.0096	0.025**	-0.0076	0.078***
	(1.36)	(2.04)	(1.24)	(3.86)	(1.49)	(2.12)	(-0.77)	(4.19)
CONS	-0.39***	0.73***	-0.41***	0.82***	-0.39***	0.57***	-0.43***	0.60***
	(-13.70)	(12.86)	(-11.89)	(11.57)	(-12.41)	(9.64)	(-9.25)	(6.73)
YEAR/IND	√	√	√	√	√	√	√	√
R-sqr	0.096	0.254	0.100	0.260	0.102	0.235	0.108	0.238
F-Value	25.8	75.9	19.4	56.0	50.3	119.3	24.7	54.9
Obs.	8126	8124	5796	5795	6917	6917	3116	3116

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

contracting (*RPT*) are distinguished. These are commodity transactions, and offering or accepting labour or capital. If such transactions exist, *RPT* =1, and 0 otherwise. The results, based on two samples grouped by related trading behaviour, are still significant, suggesting that the conclusion is not affected by related transactions.

(2) Generally speaking, senior managers of Chinese companies may also be the directors of their parent or holding companies. The relation between trade credit as the dependent variable and structural hole position as the independent variable may be affected by the holding company sending directors to the listed company. In this paper, the construction of the director network is based on the network generated by the independent directors of listed companies, so this relationship will exist if both the parent and subsidiary companies are listed and the parent company sends directors to its subsidiary. However, to the best of the author's knowledge, it is not common for both the parent and subsidiary companies to be listed, and it is even less common for the parent company to send directors to its listed subsidiary. Therefore, the large dataset used in this paper should not be affected. Of course, for the robustness test, companies in which the largest shareholder is also the director are eliminated (definition: if the director of the company also holds a post in a company that is the majority shareholder or actual controller, this takes the value of 1, and 0 otherwise), and the main results remain unchanged.

4.4 Additional analysis[18]

The regression analysis reported above shows that the structural hole position of the director network may influence the acquisition and application of trade credit. A further cross-sectional analysis is also conducted for the company's information environment, firm size, listing age, and whether it is operating in a period of tight monetary policy.

1. In order to further explore the influence of structural hole position on trade credit and the use-cost, differences in the information environment of firms are distinguished. The number of analysts is taken as a proxy for the information environment (Armstrong *et al.*, 2010). If the number of analysts following the company is more than the median, the company has a good information environment, and *INFO*=1; otherwise *INFO*=0. According to the results in Table 11, the relationship between the company's information environment, structural hole position, and trade credit is not significant, but the negative correlation between structural hole position and the use-cost of trade credit is significant in the group *INFO*=0 (at the 1% level). It is insignificant in the group *INFO*=1, suggesting that the function of structural hole position on the use-cost of trade credit is mainly found in companies with a poor information environment. Since structural hole position focuses on the advantages of having nonredundant information, compared to companies with a poor information environment, the information obtained by stakeholders from companies with a

[18] The suggestion of the anonymous reviewer is noted here with thanks.

Table 11 Information Environment, Structural Hole Position, and Trade Credit

	INFO=0	*INFO*=1	*INFO*=0	*INFO*=1
Dependent variable	*TC2_adj*	*TC2_adj*	*CASH*	*CASH*
TC			0.41***	0.39***
			(15.37)	(7.82)
*CI*TC*			-0.20***	-0.091
			(-3.39)	(-0.81)
CI	0.0016	0.0087	0.0064	-0.031**
	(0.46)	(1.04)	(0.89)	(-1.97)
SIZE	0.014***	0.018***	-0.013***	-0.0090*
	(12.32)	(6.86)	(-5.37)	(-1.80)
LEV	0.072***	0.095***	-0.23***	-0.29***
	(14.98)	(9.29)	(-23.51)	(-14.56)
MB	-0.0026	-0.0034	0.029***	0.023***
	(-1.62)	(-1.01)	(8.87)	(3.66)
INV	0.046***	0.022*	-0.44***	-0.34***
	(8.05)	(1.73)	(-37.35)	(-14.13)
OCF	0.14***	0.16***	0.44***	0.29***
	(10.49)	(5.52)	(16.30)	(5.32)
SOE	0.0083***	0.0069	0.017***	0.0097
	(3.74)	(1.41)	(3.86)	(1.05)
POST	0.015***	-0.020*	0.057***	0.032
	(3.19)	(-1.94)	(5.93)	(1.51)
CONS	-0.38***	-0.43***	0.72***	0.59***
	(-14.57)	(-7.20)	(13.56)	(5.24)
YEAR/IND	√	√	√	√
R-sqr	0.089	0.135	0.247	0.237
F-Value	28.7	10.4	89.0	18.7
Obs.	6951	5112	6951	5112

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

good information environment is redundant public information. So, structural hole position has a weak influence on decision-making behaviour. For external decision makers in companies with a poor information environment, since the information disclosed by the company or gained at a low price is limited, little redundant information is made public, and so the function of key nonredundant information gained through having more structural holes is much more obvious. In conclusion, the structural hole reflects the alternative relationship between information benefits and a company's information environment.

2. The firm's size and listing age are also distinguished. The median of firm size is calculated on the basis of year and industry. If the size of the firm is above the median, then *DSIZE*=1, otherwise *DSIZE* =0. If the company has been listed for more than two years, then *DAGE* =1, otherwise *DAGE*=0 (the results are similar if three listing years are used). The subsample results are shown in Table 12. The relationship between structural hole position and the acquisition (use-case) of trade credit mainly exists in large (large and older)

companies. For smaller and younger companies, suppliers will pay more attention to the firm’s basic significant characteristics (for instance, size or listing age), rather than its network position. It is easy for larger and more mature companies to establish basic and stable supplier-customer relations. On that basis, suppliers will consider the other factors required for contracting besides basic trust, one of which will be structural hole position based on director networks. The structural autonomy of the director network may be much stronger in such a context. According to these results, the function of structural hole position in supplier-customer trade credit contracting is in an alternative relationship with firm size and listing age.

3. Since trade credit and its use-cost are closely related to the external economic environment, in a manner similar to the work of Rao and Jiang (2013), *MP* is set as the virtual variable for a period of tight monetary policy. If the year is 2004, 2006, 2007, or 2010, then *MP* =1, otherwise *MP*=0. The results are shown in Table 13. In a period of loose monetary policy (*MP*=0), the relationship between structural hole position and the acquisition and use-cost of trade credit is consistent with expectation. However, in a period of tight monetary policy (*MP*=1), the results are no longer significant. There are two possible explanations for this. Firstly, Lu and Yang (2011) find that in a period of loose monetary policy, trade credit follows the buyer’s market theory, and in a time of tight monetary policy, it follows the theory of alternative financing. This suggests that the relationship between structural hole position and trade credit is mainly generated in a period of loose monetary policy, because more trade credit is generated in normal buying and selling activities, while the information and control benefits generated by network position mainly act on trade credit produced on the basis of the buyer’s market theory (the main logic of this paper is founded on this theory). However, in a period of tight monetary policy, trade credit acts more like alternative financing. In such circumstances, all firms are confronted by pressure of capital, so the advantages of the network structure may not be fully realised.

Secondly, network closure attaches importance to the distinct trust and specification generated by strong connections, while structural hole positions reflect the advantages of weak ties and focus on the bridging function between different branch networks. In a period of tight monetary policy, the external financing environment may get worse, and market-based trading rules may be interrupted by external policies. At such a point, the trust between network members generated by a strong connection is more significant, and the function of structural hole position becomes relatively weak. In contrast, in a period of loose monetary policy, supplier-customer trading behaviour is free from the influence of external macro-policy measures. Therefore, structural hole position based on nonredundant information may enable the advantages of information and control benefits to be fully realised. In other words, the function of structural hole position is likely to be more evident in a period of loose monetary policy.

Table 12 Structural Hole Position and Trade Credit: Evidence from Firms of Different Sizes and Listing Ages

	DSIZE=0	*DSIZE*=1	*DSIZE*=0	*DSIZE*=1	*DAGE*=0	*DAGE*=1	*DAGE*=0	*DAGE*=1
Dependent variable	*TC2_adj*	*TC2_adj*	*CASH*	*CASH*	*TC2_adj*	*TC2_adj*	*CASH*	*CASH*
TC			0.42***	0.38***			0.35***	0.39***
			(11.89)	(12.90)			(4.28)	(16.21)
*CI*TC*			-0.11	-0.27***			0.16	-0.19***
			(-1.33)	(-4.28)			(0.85)	(-3.59)
CI	0.0025	0.0012*	0.0086	-0.0049	0.0072	0.0015	-0.00014	0.00085
	(0.51)	(1.89)	(0.78)	(-0.66)	(0.92)	(0.42)	(-0.01)	(0.12)
SIZE	0.021***	0.0075***	-0.038***	0.0023	0.013***	0.016***	-0.0042	-0.0062***
	(7.71)	(4.02)	(-6.16)	(0.72)	(4.11)	(14.18)	(-0.55)	(-2.75)
LEV	0.059***	0.11***	-0.26***	-0.23***	0.10***	0.082***	-0.48***	-0.20***
	(10.39)	(14.09)	(-20.51)	(-17.32)	(6.15)	(17.63)	(-12.36)	(-21.92)
MB	0.00017	-0.012***	0.019***	0.031***	0.0075	-0.0020	0.014	0.032***
	(0.08)	(-4.57)	(4.19)	(6.74)	(1.07)	(-1.32)	(0.86)	(11.09)
INV	0.058***	0.035***	-0.44***	-0.40***	0.051***	0.047***	-0.76***	-0.35***
	(7.64)	(4.68)	(-26.25)	(-30.78)	(3.52)	(8.33)	(-22.42)	(-32.27)
OCF	0.14***	0.15***	0.37***	0.46***	0.16***	0.14***	0.60***	0.40***
	(8.24)	(8.79)	(9.72)	(15.67)	(4.82)	(11.09)	(7.39)	(15.84)
SOE	0.0060**	0.0071**	0.018***	0.016***	0.0059	0.0083***	0.013	0.019***
	(2.10)	(2.54)	(2.81)	(3.31)	(1.16)	(3.80)	(1.11)	(4.58)
POST	0.019***	0.0017	0.039**	0.037***	-0.015*	0.012**	0.030	0.022**
	(2.86)	(0.31)	(2.51)	(3.76)	(-1.74)	(2.47)	(1.45)	(2.23)
CONS	-0.53***	-0.21***	1.24***	0.38***	-0.37***	-0.42***	0.83***	0.51***
	(-8.93)	(-5.22)	(9.48)	(5.42)	(-5.29)	(-16.26)	(4.97)	(10.03)
YEAR/IND	√	√	√	√	√	√	√	√
R-sqr	0.090	0.087	0.230	0.284	0.109	0.103	0.413	0.217
F-Value	18.0	17.3	49.6	65.5	6.82	35.4	32.6	79.7
Obs.	6033	6030	6031	6030	1571	10492	1571	10490

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

4. If structural hole position has a positive role on the acquisition and application of trade credit, it is reasonable to expect that it will also promote the firm's future performance. The return on assets (*ROA*) and equity (*ROE*) after industrial adjustment and market-adjusted annual stock returns (*RET*) are adopted as proxies for corporate performance. As shown by the results,[19] in the following year, *ROA_adj*, *ROE_adj* and *RET* are all positive and significant (the coefficient is significant at the 5% and 1% level); in the following two years, the coefficient of *ROA_adj* is not significant; the significance of *ROE_adj* and *RET* declines remarkably; and their coefficients also decrease. In conclusion, the network position of the structural hole does enhance a firm's future performance.

Table 13 Monetary Policy, Structural Hole Position, and Trade Credit

	MP=0	*MP*=1	*MP*=0	*MP*=1
Dependent Variable	*TC2_adj*	*TC2_adj*	*CASH*	*CASH*
TC			0.44***	0.37***
			(15.10)	(9.28)
*CI*TC*			-0.25***	-0.060
			(-3.77)	(-0.69)
CI	0.0010*	-0.0042	0.00075	-0.0083
	(1.74)	(-0.95)	(0.09)	(-0.88)
SIZE	0.018***	0.014***	-0.0078***	-0.012***
	(13.49)	(11.02)	(-2.99)	(-4.39)
LEV	0.063***	0.098***	-0.23***	-0.25***
	(10.77)	(15.90)	(-20.55)	(-18.65)
MB	0.0029	0.0030**	0.040***	0.019***
	(1.62)	(2.10)	(11.52)	(6.31)
INV	0.015**	0.0077	-0.40***	-0.39***
	(2.47)	(1.19)	(-33.41)	(-28.18)
OCF	0.15***	0.11***	0.39***	0.52***
	(9.30)	(6.15)	(12.26)	(13.74)
SOE	0.0051*	0.0075**	0.015***	0.017***
	(1.88)	(2.57)	(2.92)	(2.81)
CONS	-0.44***	-0.37***	0.58***	0.71***
	(-15.04)	(-13.03)	(10.25)	(11.51)
IND	√	√	√	√
R-sqr	0.066	0.084	0.223	0.224
F-Value	71.5	65.3	216.6	167.6
Obs.	6915	5148	6914	5147

Note: ***, **, and * indicate 0.01, 0.05, and 0.10 significance levels, respectively. The results are clustered at the firm level.

[19] To save space, the results are not reported, but are available upon request.

V. Conclusion

According to social network theory, actors and their actions are considered as interdependent, rather than as independent and autonomous individuals, and their relationships are channels for resource transfer or flow. In a competitive product market, firms also sit within a social network, but there are few studies of firm activities from this perspective, especially in terms of network structure. For instance, Wasserman and Faust (1994) state that social capital based on social networks is often neglected, but it is a crucial factor determining the strength of a firm in a competitive product market. From a structural hole perspective, a core strategic network may bring a firm control and information benefits which enhance its strength in the product market. Moreover, the acquisition and application of trade credit reflects a firm's competitiveness, and thus it turns to be an optimal perspective for examining the influence of the position a firm holds in a social network structure on competition. In this paper, a social network is constructed through the common board memberships of directors/senior executives with an impact on the firm's decisions, and the relationship between structural hole position and the acquisition and application of trade credit is studied on the basis of this network. The results show that the more centrally positioned the firm is in a structural hole, the more trade credit it will obtain, and that this may strengthen its market competitiveness. Meanwhile, firms with more structural holes may be less sensitive to trade credit-cash holdings, so the use-cost of trade credit will be lower. It has also been shown that the influence of structural hole position on the acquisition and use-cost of trade credit is much more significant in industries with high competition and in regions with sufficient market development. This demonstrates that as a market-based contract, trade credit is impacted strongly by network position. In addition, the influence of structural hole position on trade credit is found mainly for companies which are larger and more mature; which have a poor information environment; and which are operating in a period of loose monetary policy. The conclusions of this paper are therefore of great significance for studies of corporate finance based on individual firm characteristics or which aim to propose practical solutions to the crucial problems faced by firms, such as how to gain market advantages using trade credit.

The paper does have some limitations. The definition of trade credit measures a kind of contractual relationship at different levels of the industrial chain (namely different industries). Although subdivided samples (considering the cross-industry nature of the directors and industries with typical trade credit chains, as well as the combination of both) are considered in the robustness tests, the direct logical relationship between the trade credit of firms in different industrial chains and their structural hole position cannot be identified intuitively and directly. This is a problem confronted by most of the trade credit literature and it is to be hoped that it can be considered in future studies. In addition, there are certain endogeneity problems; although their influence has been reduced in various ways in the robustness testing, it cannot be eliminated completely. As pointed out by Larcker *et al.* (2013), studies of this nature cannot eliminate all possible endogenous problems, including the causal effect, and it is only possible to attempt to reduce their influence using several technical methods.

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Appendix The Measurement of the Structural Hole Positions of Social Networks

As set out in the main text, the structural hole position is measured using the network constraint index:

$$C_{ij} = (p_{ij} + \sum_q p_{iq} p_{jq})^2,$$

where C_{ij} is the degree of constraint in the relationship investment required for the contact between firms *i* and *j*. This is impacted by two parts. P_{ij} equals the intensity of the direct connection from firm *i* to firm *j* (if a director holds posts in *i* and *j* at the same time, the two firms are considered to be directly connected). It measures the direct relationship investment of firm *i* in firm *j*. $\sum_q p_{iq} p_{jq}$ equals the sum of the intensity of nondirect connections in all paths through *q* (the path is 2) from *i* to *j*, measuring the indirect relationship investment of firm *i* in firm *j*. For convenience, academics usually take the difference between 1 and the constraint index to measure the abundance of structural holes (Burt, 1992; Zaheer and Bell, 2005). $CI_i = 1 - C_{ij}$, so the greater CI_i, the smaller the network constraint, and the more structural holes there will be in the network.

In order to better understand the algorithm of the index, they are illustrated in the following figure (with reference to Burt, 2008):

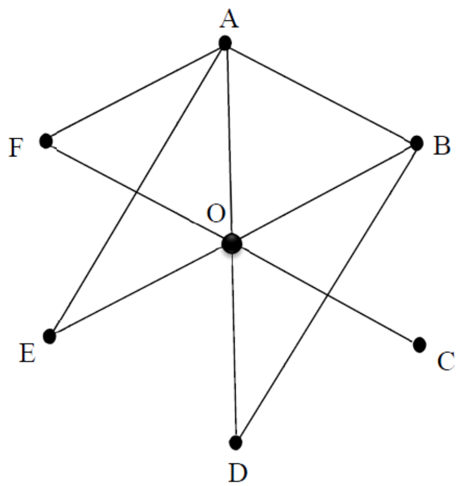

Figure A1 Measurement of the Structural Hole Position

In this network, there are seven participants; O, A, B, C, D, E, and F. The lines between two participants show that they have a direct connection, and the figure is directly connected to the matrix of the relationships. The following table is thus obtained:

Table A1 Matrix Table of Participants

	A	B	C	D	E	F	O
A	•	1	0	0	1	1	1
B	1	•	0	1	0	0	1
C	0	0	•	0	0	0	1
D	0	1	0	•	0	0	1
E	1	0	0	0	•	0	1
F	1	0	0	0	0	•	1
O	1	1	1	1	1	1	•

The method of calculation of the structural hole network position of participant O is introduced as follows. With reference to Figure A1, the calculation of the degree of constraint of the six points to O consists of two parts: the time/energy occupied by direct connections and (where the path is 2) by indirect connections. Three representative network constraint indexes C_{OC}, $C_{OD,}$ and C_{OB} are selected for illustration (this covers only a small part of the entire network constraint index of O):

Calculation of C_{OC}: As shown by Figure A1, O has six direct paths in the network, but there is only one direct relationship between C and O, so C_{OC} equals the degree of the direct path between C and O occupying the total direct relationship path of O: $(1/6)^2 = 0.028$.

Calculation of C_{OD}: similar to O-C, O has six direct paths, and there is only one direct relationship between D and O, but the difference is that there is an indirect relationship between O and D: O-B-D. The degree of indirect connection controlled by B equals the control degree of O-B as a multiplier of the control degree of D-B. P_{OB} is 1 (there is one direct path between B and O) divided by 6 (O has six direct paths): 1/6. Similarly, P_{BD} is 1 (there is only one direct path between B and D) divided by 3 (B has three direct paths), namely 1/3, and then the indirect relation path between O and D is (1/6*1/3) = 1/18; therefore, $C_{OD} = (1/6+1/18)^2 = 0.049$.

Calculations of C_{OB}: the degree of direct relationship of O and B is similar to the previous conditions, but there are two indirect paths, O-A-B and O-D-B. The degree of the constraint of the indirect connection between O and B is the sum of the constraints of the two paths. Similar to the algorithm given above, this is (1/6*1/4) + (1/6*1/2) = 1/8; therefore, $C_{OB} = (1/6+1/8)^2 = 0.085$.

The calculation methods of C_{OA}, $C_{OE,}$ and C_{OF} are similar and will not be repeated here. The specific results are shown in the following table.

Table A2 Sample Calculation of C_{ij}

C_{ij}	C_{OA}	C_{OB}	C_{OC}	C_{OD}	C_{OE}	C_{OF}	$C_O = C_{OA} + C_{OB} + C_{OC} + C_{OD} + C_{OE} + C_{OF}$
Value	0.151	0.085	0.028	0.049	0.043	0.043	0.399

After calculating the degree of constraint of O and each point in the figure, according to the equation $C_i = \Sigma_j C_{ij}$, the total network constraint index of O in the network can be obtained: $C_O = C_{OA} + C_{OB} + C_{OC} + C_{OD} + C_{OE} + C_{OF} = 0.399$.

After obtaining the network constraint index of the participant O, according to the equation $CI_i = 1 - C_{ij}$, the abundance of structural holes for participant O can be calculated: $CI_O = 1 - 0.399 = 0.601$.