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National Systems of Entrepreneurship: Measurement issues and policy implications

Zoltán J. Ács[a,1], Erkko Autio[b,c,*,1], László Szerb[d,1]

[a] School of Public Policy, George Mason University, Fairfax, VA 22030, USA
[b] Imperial College Business School, London SW7 2AZ, UK
[c] Aalto University, Department of Industrial Engineering and Management, 02150 Espoo, Finland
[d] University of Pécs, Faculty of Business and Economics, Rákóczi 80 H-7622, Pécs, Hungary

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ABSTRACT

We introduce a novel concept of National Systems of Entrepreneurship and provide an approach to characterizing them. National Systems of Entrepreneurship are fundamentally resource allocation systems that are driven by individual-level opportunity pursuit, through the creation of new ventures, with this activity and its outcomes regulated by country-specific institutional characteristics. In contrast with the institutional emphasis of the National Systems of Innovation frameworks, where institutions engender and regulate action, National Systems of Entrepreneurship are driven by individuals, with institutions regulating who acts and the outcomes of individual action. Building on these principles, we also introduce a novel index methodology to characterize National Systems of Entrepreneurship. The distinctive features of the methodology are: (1) systemic approach, which allows interactions between components of National Systems of Entrepreneurship; (2) the Penalty for Bottleneck feature, which identifies bottleneck factors that hold back system performance; (3) contextualization, which recognizes that national entrepreneurship processes are always embedded in a given country's institutional framework.

1. Introduction

Since the days of Schumpeter (Schumpeter, 1934), economists have agreed that entrepreneurs are somehow important for economic development. Schumpeter famously stated that entrepreneurs are 'agents of creative destruction', who introduce change to the economic landscape by constantly undermining and challenging established industry incumbents. Subsequently, researchers have argued a whole array of economic benefits generated by entrepreneurs, ranging from innovation (Acs and Audretsch, 1988) to job creation (Blanchflower, 2000; Parker, 2009) to productivity (van Praag, 2007) to, e.g., facilitation of technology transfer and knowledge spill-overs from research to industry (Acs et al., 2009a; Grimaldi et al., 2011; Plummer and Acs, 2012; Terjesen and Wang, 2013). Whatever the specific contribution, the broad consensus is that entrepreneurship matters. To provide policy-makers with means of facilitating the economic contributions of entrepreneurship, it is therefore important to provide them with up-to-date measures of the phenomenon.

This is where things get tricky, however. What do we actually mean when we talk about 'entrepreneurship'? A standard way of kicking off any doctoral seminar in entrepreneurship is to start with a debate on how entrepreneurship should be defined. Should it be defined as activity such as self-employment or new firm creation (e.g., Reynolds et al., 2005)? Or as firm-level behavioral disposition such as 'entrepreneurial orientation' (e.g., Lumpkin and Dess, 1996)? Or as an individual-level cognitive attribute such as opportunity perception (e.g., Shane and Venkataraman, 2000)? In spite of years of research, entrepreneurship is a fiendishly difficult concept to pin down. This makes measurement challenging.

The measurement challenge becomes even more complex when discussing entrepreneurship in countries (e.g., Audretsch, 2007b; Djankov et al., 2003; Reynolds et al., 2005). If we have difficulty defining entrepreneurship as an individual- or firm-level phenomenon, what hope do we have of deciding what 'entrepreneurship' means as a country-level phenomenon? Although pinning down the concept is even more complicated at the country level, received approaches to measuring entrepreneurship at the country level usually side-step the consideration of definitional questions. Instead, they proceed direct to providing country-level measures without providing adequate theoretical or conceptual grounding for the measurement approaches chosen. The result is a plethora of measures of country-level 'entrepreneurship' that often do not really speak to one another.

* Corresponding author at: Imperial College Business School, London SW7 2AZ, UK. Tel.: +44 7786226452.
E-mail addresses: zacs@gmu.edu (Z.J. Ács), erkko.autio@imperial.ac.uk (E. Autio), szerb@ktk.pte.hu (L. Szerb).
[1] Authors listed alphabetically.

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A major reason underlying the country-level measurement problem is that entrepreneurship has never received adequate treatment as a country-level phenomenon. To cite an example, the core works of the National Systems of Innovation literature hardly ever even evoke the term 'entrepreneurship'—and even then, usually as anecdotal examples or in reference to Schumpeter's Mark I and Mark II models (e.g., Freeman, 1995; Lundvall et al., 2002). Similarly, received economic growth theories are silent about entrepreneurship (e.g., Acs and Sanders, 2012; Romer, 1986). This perhaps explains why arguably the largest number of country-level entrepreneurship indicators are simple aggregates of individual-level activity—and why a 'systemic' understanding of the role of entrepreneurial activity in national and regional economies remains under-developed (Gustafsson and Autio, 2011; Radosevic, 2007).

In this paper, we build the argument that, at the country level, entrepreneurship should be treated as a systemic phenomenon, similar to the way the literature on 'National Systems of Innovation' treats country-level infrastructures, policies, and institutions when considering factors that determine a country's ability to produce and take advantage of scientific discoveries and technological innovation (Kenney, 2000; Lundvall et al., 2002; Nelson, 1993). We think that adopting a systemic approach to considering the entrepreneurial performance of countries is important not only because it provides a more realistic portrayal of the phenomenon, but also, because it helps researchers and policy-makers think in systemic terms and take a broad perspective when considering both individual- and country-level indicators of entrepreneurial action. A systemic approach is also helpful when designing policies to nurture and leverage entrepreneurship for sustainable economic development. Although there have been numerous studies at the regional level – notably, in high-technology clusters such as the Silicon Valley and Route 128 – (see, e.g., Adams, 2011; Kenney and von Burg, 1999; Klepper, 2010) there have been virtually no studies applying a systemic approach to understand the entrepreneurial performance of countries (for an exception, see Busenitz et al., 2000).

We do three things in this paper. First, we review ongoing attempts to measure entrepreneurship at the national level, highlighting their distinctive features, strengths, and shortcomings. Second, we provide a conceptual discussion of the notion of 'National Systems of Entrepreneurship' and elaborate why and how country-level entrepreneurship should and does exhibit systemic characteristics. Third, we propose a method to characterize National Systems of Entrepreneurship in a way that captures key systemic properties—notably, imperfect substitutability between the constituent parts of the system as well as the existence of possible bottleneck factors that hold back system performance.

In what follows, we propose a definition of National Systems of Entrepreneurship that addresses some of the challenges of the current implied definitions—i.e., de-contextualization and decomposition. We argue that National Systems of Entrepreneurship cannot be properly understood without considering *both* population-level processes (attitudes, ability, and aspirations) *and* the institutional context within which these processes are embedded. Furthermore, any systemic approach to measure country-level entrepreneurship has to allow system components to interact to produce system performance. This implies that system performance can be held back by *bottleneck factors*—i.e., poorly performing system components. Following these principles, we construct a Global Entrepreneurship and Development Index (GEDI), which consists of three sub-indices (reflecting attitudes, ability, and aspirations) and a total of fifteen individual pillars that reflect the various aspects of the dynamic interaction that drives productive entrepreneurship in a given country.

2. Defining National Systems of Entrepreneurship

Although the systems approach to understanding innovation remains attractive in social sciences, there have been shifts in emphasis over the years. Early on, one of the main missions of the 'National Systems of Innovation' (NSI) literature was to debunk the linear model of innovation and emphasize and illustrate the interactive, iterative, and cumulative aspects of innovation processes in national contexts (e.g., Freeman, 1987, 1988; Freeman and Lundvall, 1988; Lundvall, 1988; Lundvall et al., 2002). This concept became influential because its focus on institutions and structure gave policy-makers a framework to understand and facilitate national innovation performance (Nelson, 1993). However, with its focus on structure, the NSI literature tended to overlook individual agency (Hung and Whittington, 2011). This meant that the NSI framework was only poorly equipped to understand emergence in innovation systems (Gustafsson and Autio, 2011). Therefore, while this 'techno nationalist' (Montresor, 2001; Niosi et al., 1993; Ostry and Nelson, 1995) emphasis on national institutions was attractive in the 1990s and early 2000s, the last decade has witnessed a steady increase in interest in the role of entrepreneurship and individual agency in driving innovation in countries (Acs et al., 2009a; Audretsch et al., 2006; Mueller, 2006).

2.1. National Systems of Innovation

The concept of National Systems of Innovation burst onto the policy scene in the early 1990s with the publication of three books (Edquist and Johnson, 1997; Lundvall, 1992; Nelson, 1993). The main theoretical underpinnings were that knowledge is a fundamental resource in the economy, that knowledge is produced and accumulates through an interactive and cumulative process of innovation that is embedded in a national institutional context, and that the context therefore matters for innovation outcomes (Lundvall, 1999). In the NSI literature, the notions of interaction and knowledge accumulation shifted emphasis from individual R&D processes towards the institutional and industrial structure within which those processes were embedded. A key message was that it is this structure (rather than individual R&D processes) that ultimately determines the innovation productivity of nations. Some of the most influential works in this area were that of Richard Nelson, who conducted an international research project comparing 15 countries using a similar methodology (Nelson, 1993); of Bengt-Åke Lundvall, who drew attention to user-producer interactions in innovation systems (Lundvall, 1992), and Chris Freeman, whose early studies of the 'Japanese system of innovation' provided an influential intellectual guidepost for subsequent research (Freeman, 1988). The systems approach was subsequently expanded to consider also technologies, institutions, organizations, and industries in addition to countries (Edquist and Johnson, 1997; Malerba and Breschi, 1997).

It is important to understand what a 'system' means in the NSI literature. According to Rosenberg and Nelson (1994: 4–5), the term 'system' connotes: "*. . .a set of institutions whose interactions determine the innovative performance. . .of national firms. There is no presumption that the system was, on some sense, consciously designed, or even that the set of institutions evolved works together smoothly and coherently*." The system concept, "*. . .is that of a set of institutional actors that, together, plays the major role in influencing innovative performance*". Systems constitute of multiple components that work together to produce system performance. In the NSI literature, systems are not created. Rather, they are inherited, evolving structures, and the key task of the researcher is to understand this structure so the system could be rigged to deliver improved performance.

It is perhaps a little surprising, if not even ironic, that although the NSI literature was heavily influenced by the Schumpeterian

tradition, the entrepreneur remained conspicuously absent in this literature. The NSI literature is quite firmly rooted in the Schumpeter 'Mark II' tradition, which emphasized the role of large corporations in R&D (Freeman, 1997). In contrast, Schumpeter's earlier ideas on the role of entrepreneurs as agents of creative destruction have been largely overlooked. As an illustrative example, Freeman's (1995) article used the term 'entrepreneurship' only twice, both times when providing anecdotal examples. Lundvall et al.'s (2002) article similarly accorded only two passing mentions of the term without integrating it into the theoretical structure. Even at the sectoral level, Malerba and Breschi (1997) treatment only mentioned entrepreneurship when explaining the difference between Schumpeter's Mark I and Mark II models. The two literatures, those of NSIs and entrepreneurship, have largely developed in parallel, independent of one another, even though the concepts of innovation and entrepreneurship themselves are closely related, and both literatures trace at least some intellectual descent from Schumpeter.

This omission of agency, in combination with the dominant focus on (inherited) structure, has given the NSI literature quite a static flavor. The structure predominates, and changes within the structure somehow emerge through institutional interactions, knowledge flows, and competence accumulation. But: *'There is an inherent risk that "system" brings with it a structuralist mode of explanation that neglects the critical role of agency*' (Lundvall, 2007: 110). To address this gap and make the NSI concept more dynamic, Hung and Whittington (2011) attempted to introduce endogenous agency to the NSI literature in the form of institutional entrepreneurship, defined as individual agency aiming at transforming existing institutions and creating new ones. However, institutional entrepreneurship is not entrepreneurship (Perkmann and Spicer, 2007). In a related discussion, Gustafsson and Autio (2011) pointed to 'inhibited emergence' (in addition to structural inertia) as a failure mode in innovation systems. In their discussion, inhibited emergence related to the absence of entrepreneurial experimentation that challenged established development paths, whereas structural inertia related to the failure of established structures to adapt to support new innovation modes. However, they did not explicitly elaborate on the role of entrepreneurship in alleviating these failures, although the 'inhibited emergence' failure mode is clearly compatible with entrepreneurial experimentation.

Summarizing, entrepreneurs remain mostly absent in the NSI conversation. Radosevic (2007) ascribed this gap to the predominantly institutional emphasis of the NIS literature, which has made it difficult to accommodate the individual-centric perspective of the entrepreneurship literature (Shane, 2003). In the institutional tradition of the NIS literature, institutions engender, homogenize, and reinforce individual action: it is a country's institutions that create and disseminate new knowledge and channel it to efficient uses. In this perspective, individual action is either not considered or is supposed to happen automatically, subject to the homogeneizing influences of the country's institutions. This routine-reinforcing perspective of NSIs has proven difficult to reconcile with the individual-centric, routines-breaking emphasis of the entrepreneurship literature (Radosevic, 2007; Schmid, 2004).

2.2. National Systems of Entrepreneurship

The other side of the coin has been the failure of the entrepreneurship literature to systematically consider the wider, system-level constraints and outcomes of entrepreneurial action. Although Schumpeter (1934) elaborated on the role of entrepreneurship as a novelty-introducing function in economic landscapes, this aspect has not been properly picked up by entrepreneurship researchers, who have tended to focus on the individual and on the new venture while largely ignoring the consideration of system-level constraints and outcomes (Shane and Venkataraman, 2000).

The closest economic theorizing about entrepreneurship has come to elaborating on the functional role of entrepreneurship in economic systems has been through the work of the 'Austrian' economists[1] such as Von Mises, Hayek, and Kirzner. In his summary of this theorizing, Kirzner (1997, 1973) emphasized the *function* of entrepreneurship as a market discovery process: by initiating and reacting to one another's competitive actions, 'entrepreneurs' (i.e., 'entrepreneurially alert' individuals) uncover and exploit failures in the market pricing mechanism. However, this approach relegated the individual into a black box: although opportunity discovery by individuals was considered a central mechanism driving the market process, opportunity pursuit was assumed to automatically and immediately follow discovery (Autio et al., 2013a; McMullen and Shepherd, 2006). Entrepreneurship was treated as a central aspect of the human condition, rather than emanating from individual choice: "*In any real and living economy every actor is always an entrepreneur*" (Von Mises, 1949:253). However, Kirzner did not actually see the entrepreneur behind the function he performed. This meant that the crucial regulators of individual action – i.e., motivations, perceptions, desires, cognition, and judgment – were not elaborated in the theory beyond the simplistic assumption that 'discovery' triggers immediate action.

This same abstraction is manifest in the rare occasions where the NSI literature has attempted to address entrepreneurship (Radosevic, 2007). In Radosevic's unpublished portrayal, entrepreneurship was treated à la Kirzner as a function of NSIs: National Systems of Innovation produce and regulate three kinds of opportunities: technological, market, and institutional. These objectively and independently existing intermediary products of the NSI are then combined and taken advantage of through entrepreneurial experimentation, which is treated as a function of NSIs. But the individual is not given much consideration: "*Who is performing the entrepreneurial function is a 'secondary' issue compared to the primary issue of what entrepreneurship activity takes place.*" (Radosevic, 2007:15). Radosevic's portrayal thus remains true to the 'classic' NIS tradition in its rather abstract and non-personalized treatment of entrepreneurs. This treatment of the entrepreneur as a function rather than an individual precludes the consideration of the origins and regulators of individual agency.

In contrast to the NSI literature, individual judgments and action occupy the central position in the entrepreneurship literature. Central to the entrepreneurial process is not whether or not opportunities exist (in the absence of 'objective' opportunities, entrepreneurs can always create their own (Alvarez and Barney, 2007)), but rather, what is done about them and by whom (Companys and McMullen, 2007; Shane, 2003; Shane and Venkataraman, 2000). Thus, *action* by individuals, and determinants and regulators thereof (rather than the production of opportunities), becomes key to the entrepreneurial process. The objective existence of opportunities independent of entrepreneurs does not really matter, as long as the individual forms a conjecture that an opportunity exists and its pursuit is feasible and desirable (McMullen and Shepherd, 2006). In this portrayal, individuals observe third-person opportunities around them and evaluate the feasibility and desirability of their pursuit (Autio et al., 2013a). Feasibility and desirability considerations can be influenced by contextual factors, such as resource availability and social norms and attitudes—although these are not explicitly elaborated in the action theory of entrepreneurship. However, this action-centric approach and other similar approaches in individual- and

[1] Interestingly enough, although an Austrian, Schumpeter is not considered to be an 'Austrian' economist.

firm-centric entrepreneurship research do not consider the wider effects of entrepreneurial action. Thus, the feedback loop from action to system-level outcomes remains open.

We propose that a way out of this 'institutions vs the individual' dilemma is to think about the role of the entrepreneur's context not only as regulators of opportunities and personal feasibility and desirability considerations for entrepreneurial action, but also, as the regulator of the *outcomes* of entrepreneurial action. From a systems perspective, we propose that it is useful to emphasize the resource mobilization aspect of entrepreneurial action. At the system level, resource mobilization creates a process of 'entrepreneurial churn' (Reynolds et al., 2005), which drives resource allocation to productive uses through a process of entrepreneurial trial and error (Bartelsman et al., 2004). If this resource allocation process is to operate efficiently – that is, allocate resources to the most productive uses – three conditions need to be satisfied: first, the right individuals need to form conjectures that entrepreneurial action is desirable and feasible; second, the right individuals need to act and initiate new firm attempts that are likely to channel resources to productive uses; and third, that the new firm attempts are allowed to realize their full potential.

In short, we propose that a National Systems of Entrepreneurship perspective should emphasize the interactions between individuals and their institutional contexts in producing entrepreneurial *action* and regulating the quality and outcomes of this action. Any definition of National Systems of Entrepreneurship should recognize that entrepreneurship is fundamentally individual-level behavior; which mobilizes resources for opportunity pursuit through the creation of new firms; which is driven by complex population-level interactions between attitudes, aspirations, and ability; which is embedded within a multifaceted economic, social, and institutional context; and which drives economic productivity through the allocation of resources to efficient uses. Consequently, propose the following definition of National Systems of Entrepreneurship:

> A National System of Entrepreneurship is the dynamic, institutionally embedded interaction between entrepreneurial attitudes, ability, and aspirations, by individuals, which drives the allocation of resources through the creation and operation of new ventures.

Our definition differs from Kirzner's (1997) conception of entrepreneurship as a market discovery process. In Kirzner's conception, entrepreneurs drive market learning and price discovery by initiating and reacting to competitive actions. Our emphasis is similar when it comes to learning, but we place greater emphasis on resource access and mobilization and associated knowledge accumulation as a trial-and-error process. For Kirzner, opportunities were real, objective, and existed in the marketplace independent of human action. Thus, the Kirznerian notion of 'opportunity discovery' referred to an instantaneous event when an entrepreneur stumbled upon a price inefficiency in the marketplace. For Kirzner, this was the essential function of the entrepreneur. We suggest that, in addition to helping iron out inefficiencies in the market pricing mechanism, perhaps a more important effect of entrepreneurship is produced when entrepreneurs act upon opportunities they *perceive*, regardless of whether these are real or not (see also McMullen and Shepherd, 2006).

When acting upon perceived opportunities, entrepreneurs mobilize human, financial, and other resources. If the entrepreneur's perception proves incorrect, or if the entrepreneur commits errors in organizing resources, the venture will fail and its resources will be released for other uses. If, however, the entrepreneur's foresight proves correct, and the entrepreneur is successful in resource organization, the venture will prove profitable and attract additional resource investment up to a level set by market size, competitive offerings and the entrepreneur's ambition. The system-level emergent outcome of a multitude of such decisions is resource reallocation towards productive uses, which should eventually reflect in total factor productivity. To avoid tautology, our definition omits the qualification of this process as productivity-enhancing. However, there is considerable evidence to suggest that the quality of entrepreneurial efforts matters and should be captured by any attempt to measure national entrepreneurship (Autio, 2011; Baumol, 1990; Birch et al., 1997; Schrerer, 2000; Stenholm et al., 2013).

Before we turn to the measurement issues implied by our theoretical discussion, we first review received attempts to measure entrepreneurship as a country-level phenomenon.

3. Existing approaches to measuring entrepreneurship in countries

Existing approaches to measuring entrepreneurship in countries can be broadly assigned to three categories: output, attitude, and framework indicators. The different approaches imply different conceptions of country-level entrepreneurship. In the following we review each approach.

3.1. Output measures

Output indicators track the emergence or registration of new self-employment or new firms within a given population. In these measures, entrepreneurship is conceived of as the creation of a new business organization or an entry into self-employment. Aggregated at the national level and normalized by population size, these are essentially density measures. The most widely referred output indicator is the Global Entrepreneurship Monitor GEM, which records the self-employment rates annually in an annually changing sample of 50–70 countries (Reynolds et al., 2005). Other output measures include OECD-Eurostat's Entrepreneurship Indicators Program (Lunati et al., 2010; OECD-Eurostat, 2007), World Bank's Entrepreneurship Survey (World_Bank, 2011), and the Flash Eurobarometer survey (Gallup, 2009).

The Global Entrepreneurship Monitor estimates national self-employment rates with representative random samples of at least 2000 adult-age individuals within a country. Four screening questions are used to identify either nascent, new, or established entrepreneurs. Nascent businesses have not paid salaries for longer than 3 months, whereas new businesses have not paid salaries for longer than 42 months.

The most widely used GEM measure of national entrepreneurship combines the adult population prevalence rates of nascent and new businesses into a total early-stage entrepreneurial activity (TEA) rate. Also sub-indices have been developed, which isolate sub-sets of the general self-employment population. The most important of these is GEM's high-aspiration entrepreneurship index, which refers to the prevalence rate of nascent and new entrepreneurs who expect to employ at least 20 employees within five years' time (Autio, 2007).

Whereas the GEM index is based on random sampling of the adult population, the OECD and World Bank indices draw on data from national registries. The OECD high-growth firm indicator draws on business registries, central chamber of commerce registries, and other such public registries to create an index of the prevalence (relative to the overall population of registered companies) of high-growth firms. In the OECD definition, a high-growth firm is a registered firm (trade registry, employment registry, or such) that has achieved at least 60% employment growth during a period of two years, with at least 20% annual growth in each, and which employed at least 10 employees at the beginning of the

period (OECD-Eurostat, 2007). Thus, in the light of the OECD index, national entrepreneurship translates into the prevalence rate (relative to the population of registered firms) of firms that exhibit rapid employment growth above a given size threshold.

Similarly to OECD, the World Bank Entrepreneurship Survey relies on business registry data to monitor the birth of new business entities in the formal sector. This survey is based on national registries to monitor new firm entries, defined as registrations of private companies with limited liability. In the World Bank definition, entrepreneurship is defined as: "*The activities of an individual or a group aimed at initiating economic enterprise in the formal sector under a legal form of business*" (Klapper and Love, 2010: 4). As with the OECD approach, the reliance on public registries means that the data is not strictly comparable across countries due to differences in registration practices. This approach also does not distinguish between de novo entries and, for example, reorganizations of existing businesses. Further, this approach misses out on new firms that do not register for any reason. This problem is particularly relevant in developing economies, as illustrated by Klapper and Love's (2010) finding that entry density (new firm registrations per adult-age population) in low-income countries is less than tenth of that of high-income countries. Indeed, some estimates suggest unregistered versus registered entry ratios greater than 100:1 in some developing economies (Acs et al., 2008; Autio and Fu, 2012).

In summary, output measures of entrepreneurship monitor new firm entries in the economy, using either survey or registry data. The advantage of survey data is that it tracks genuinely entrepreneurial entries (i.e., an individual or a group of individuals would become owner-managers of the venture); is able to isolate pertinent sub-groups of entries (e.g., high-growth aspiration entries); and is able to standardize the data across countries. The advantage of registry data is that it tracks formal, and therefore, presumably more consequential new entries. However, the two approaches can provide very different views into entrepreneurship.

3.2. Attitude measures

A number of global opinion and value surveys exist, and some of these track opinions, values, and attitudes that are relevant for entrepreneurship. Perhaps the best known of these is the Eurobarometer survey, which has been conducted since 2000 (Gallup, 2009). Other sources of entrepreneurial attitudes include the GEM survey (which also tracks attitudes) and the International Social Survey (ISSP, 1997). Of these, the Eurobarometer survey is clearly the most extensive, and it has been extended in recent years also to cover entrepreneurial activity.

Depending on survey, attitude surveys monitor a range of attitudes relating to entrepreneurship. These include: preference for being self-employed; reasons for preferring self-employment (or not); attitudes towards entrepreneurs (including success and failure); and self-efficacy perceptions. Combined, such measures provide valuable evidence on the feasibility, desirability, and legitimacy considerations associated with the decision to become self-employed.

While attitude surveys provide an insight into the opinion climate that prevails in a given country, they tend to suffer from the obvious disassociation from actual activity. Therefore, at best, opinion surveys give us a rough pointer into the potential for self-employment activity that prevails in a given country (Blanchflower et al., 2001). However, attitude surveys tell us little about how opinions and attitudes translate into action within a given context, although theory suggests that both feasibility and desirability considerations should play a role (McMullen and Shepherd, 2006).

3.3. Framework measures

Three types of framework measures exist. One approach surveys national experts with a mail questionnaire to construct multi-item scales that reflect entrepreneurial framework conditions. An example of these is the Global Entrepreneurship Monitor's National Expert Survey (Reynolds et al., 2005). Another approach compares the national regulatory framework for new business entry (Djankov et al., 2002). This effort has produced the widely used World Bank 'Ease of Doing Business' index. Partly building on this effort, OECD Entrepreneurship Indicators Program has developed a more comprehensive framework measure that distinguishes between framework conditions, entrepreneurship performance, and economic impact (Ahmad and Hoffmann, 2008).

The World Bank 'Ease of Doing Business' database collects data on the regulatory framework relevant for the registration of new limited liability companies. Here, the focus is on highly tangible indicators of the regulatory environment, such as the number of procedures required to register a new business; the number of days required to complete a new business registration; minimum capital requirement for new limited liability companies (as % of GDP per capita); procedures and cost to build a warehouse; creditor recovery rate in bankruptcy events; and so on. On the other hand, the EDB does not inform on actual new firm creation activity. Another limitation is that the data is restricted to a 'standardized' company that, among others, is registered, employs from 5 to 50 employees within the first month of operation, and has sales turnover of up to 10 times start-up capital (Djankov et al., 2002). This means that the EDB framework conditions may or may not apply to well over 90% of the new firm population in any given country.

The Entrepreneurship Indicators Program (EIP) by the OECD builds on the framework conditions – entrepreneurship performance – (economic) impact model developed by Ahmad and Hoffmann (2008; see also Nordic_Council, 2010). This approach builds on and extends research into entrepreneurship policies initiated by the Danish government and policy research think tank FORA, and it also draws on other initiatives such as the World Bank Ease of Doing Business index, the World Bank Entrepreneurship Survey, and the OECD's efforts to track various forms of new business registrations and exits (Ahmad and Hoffmann, 2008; Hoffmann et al., 2006). In this model, entrepreneurship performance (i.e., the registration and growth of new limited liability companies) is regulated by entrepreneurship framework conditions. However, the link between framework conditions and entrepreneurship performance remains a conjecture rather than a statistically established relationship. Demonstrating this link statistically may prove challenging, given the all-encompassing definitions employed (Ahmad and Hoffmann, 2008: 8).

Summarizing, framework indicators provide useful benchmarks of the institutional and regulatory conditions that prevail in the economy. However, they lack connectivity with actual activity. In this perspective, an entrepreneurial country is one where the regulations and broader institutional conditions are supportive of entrepreneurial actions, regardless of whether such activity occurs and in which form. A further limitation of the regulations-focused framework indices is that they can only target registered activity, and the 'standardized' approach overlooks up to the majority of self-employment attempts and new firm formations, depending on country.

3.4. Implications for profiling National Systems of Entrepreneurship

The above review has uncovered important differences in explicit and implicit definitions of entrepreneurship in countries. It is clear that the different approaches have been developed for

different purposes, and each has their own distinctive merits. The proliferation of definitions nevertheless cries out for a discussion of how entrepreneurship should be defined and measured in countries. The definitional discussion was provided above. We next turn to the measurement challenge.

Our literature review revealed widespread acceptance that innovative processes exhibit systemic properties when studied at the country level. There is good reason to believe that also the dynamics of entrepreneurship at the country level can be best understood in systemic terms. First, empirical data shows significant differences between countries in terms of population prevalence rates of new firm creation—even between countries at similar levels of economic development (Bosma et al., 2009; World Bank, 2011). This is consistent with the notion that entrepreneurial performance is driven by complex, systemic interactions, the balance of which would be likely to vary across countries. Second, differences across countries are persistent over time—suggesting that entrepreneurial performance is driven by path-dependent processes (Levie and Autio, 2011). Third, there is widespread empirical and theoretical recognition that individual-level entrepreneurial action is regulated by contextual factors, such as culture, formal institutions and resource availability (Aldrich and Fiol, 1994; Autio and Acs, 2010; Carroll et al., 2000; Djankov et al., 2006; Hayton et al., 2002; Phan, 2004).

Although evidence supporting systemic influences is relatively widespread, the implications of this evidence for entrepreneurship research are insufficiently developed–both at country and individual levels. The broad outlines of our measurement approach derive from the challenges and shortcomings we identified in our review of existing measures of country-level entrepreneurship:

1. Lack of contextualization in output indicators. If entrepreneurship at the country level is proxied as the aggregate of new firm registrations (or similar), it is implicitly assumed that: (a) the economic implications of new firm formations are the same regardless of the national context; and (b) that additional entry events will exhibit the same marginal utility regardless of the context in which the firm creation occurs. Both assumptions are open to challenge and may lead to erroneous policy prescriptions if blindly followed.
2. The use of national aggregates of individual-level behaviors and attitudes to provide a national-level proxy of the phenomenon risks masking the mechanisms through which individual-level entrepreneurial activity contributes to economic growth. More firm creations (or even high-growth firm creations) may not automatically translate into economic growth, and it is also not evident that more positive general attitudes would automatically translate into more active entrepreneurial behavior by individuals.
3. Although framework indicators provide valuable information regarding the context in which entrepreneurial processes operate, they tell little about those processes themselves. At present, there exists too little longitudinal data to convincingly demonstrate a link between institutional conditions and entrepreneurial performance, and received evidence is anecdotal at best.
4. In addition to lacking contextualization, focus on outputs tells us little about the processes that drive those outputs—e.g., how and when attitudes drive behaviors.

We repeat that all of the reviewed measurement approaches have their own distinctive merits, and the above criticisms have been made strictly from the perspective of defining National Systems of Entrepreneurship. In the following, we draw on the above review and propose a composite index methodology to profiling National Systems of Entrepreneurship.

4. Profiling National Systems of Entrepreneurship: proposed approach

We propose that an empirically and conceptually sound approach to measuring National Systems of Entrepreneurship should conceive of National Systems of Entrepreneurship as a dynamic interaction between entrepreneurial attitudes, ability, and aspirations; consider entrepreneurial processes within their institutional contexts; and recognize the multifaceted, multi-level nature of the phenomenon (Acs et al., 2013). Methodologically, these considerations suggest that:

1. To reflect the multi-faceted nature of National Systems of Entrepreneurship, the index should comprise a broad range of components.
2. To provide appropriate contextualization, the index should include measures of the various system-level framework conditions in addition to individual-level measures.
3. To appropriately reflect system dynamics, the index should allow interactions between system components.

We next discuss our approach to addressing points 2 (contextualization) and 3 (systemic interactions) first. We then discuss individual components used to address the multi-faceted character of country-level entrepreneurship. This is followed by empirical illustration using 2012 or most recent data.

4.1. Addressing contextualization: contextual weights

Most indices do not use weighting. Without weights, index calculation is relatively easy, and also non-professionals can interpret the index in a straightforward fashion. For example, the Ease of Doing Business index and the Index of Economic Freedom follow this approach. However, weighting is useful when the different components of the index are thought to have a different influence on the phenomenon to be captured. This, however, raises the question of how to assign appropriate values to weights. Most index weighting methods are criticized for being arbitrary and unable to provide a normalized reference point across countries. We develop a novel index methodology that is designed to address the problems of arbitrariness and cross-country normalization.

We proposed that an entrepreneurship index should incorporate individual-level as well as contextual (institutional) variables. This is important, not only to contextualize the index, but also, to reflect the notion that different index components might 'produce' different outcomes in different country settings. For example, market-expanding start-ups might generate a stronger influence on economic development in countries where market entry is not artificially restricted. In other words, the ability of entrepreneurial firms to generate an economic impact may be regulated by the systemic context within which the venture is embedded. For this reason, we chose to weigh the country aggregates of individual-level data on attitudes, ability, and aspirations with appropriate descriptors of context.

The novelty of our approach is that we use the institutional variables as interaction components, not as stand-alone variables. We enter institutional variables into the index as weights that are combined with aggregated individual-level data. A major advantage of this approach is the incorporation of country differences into the index. This interaction approach also alleviates the arbitrariness problem associated with the use of author-assigned weights that are not traced back to observable conditions within individual countries. Finally, with the interaction procedure, context is introduced as a regulating influence into the index.

Although the interaction approach alleviates the arbitrariness problem, the choice of the institutional weights themselves can

Table 1
Description of the individual-level variables used in GEDI (national aggregates are used).

Individual variable	Description
Opportunity recognition	Percentage of the 18–64 year old population indicating belief that there will be good opportunities to start a new business in the area where they live over the next 6 months' time
Skill perception	Percentage of the 18–64 year old population claiming to possess the required knowledge and skills to start a new business
Risk acceptance	Percentage of the 18–64 year old population stating that fear of failure would not prevent them from starting a business
Know entrepreneurs	Percentage of the 18–64 year old population indicating that they personally know someone who has started a new business in the past 2 years
Career	Percentage of the 18–64 year old population stating that people in their country consider starting a new business to be a good career choice
Status	Percentage of the 18–64 year old population stating that people in their country accord high status to successful entrepreneurs
Career status	Calculated as the average of career and status
Opportunity motivation	Percentage of TEA (total early-stage entrepreneurial activity) businesses initiated because of opportunity start-up motive
TEA female	Ratio between female TEA and male TEA (1:1 ratio is considered the best value, and deviations from this ratio to either direction are considered sub-optimal)
Technology level	Percentage of TEA businesses that are active in high or medium technology sectors
Educational level	Percentage of TEA businesses with owner–managers having participated in at least secondary education
Competitors	Percentage of TEA businesses started in those markets where not many businesses offer the same product
New product	Percentage of TEA businesses offering products that are new to at least some customers
New Tech	Percentage of TEA businesses using new technology that is less than 5 years old
Gazelle	Percentage of TEA businesses exhibiting high employment expectations (i.e., expecting to have more than 10 employees in five years' time, representing at least 50% increase in employment size relative to current employment size)
Export	Percentage of TEA businesses indicating that at least some of their customers are abroad
Informal investment (mean)	Mean amount of informal investment by individuals over the past 3 years
Business Angel	Percentage of the 18–64 year old population who provided funds for new entrepreneurial businesses started by others
Informal investment	Calculated as [Informal Investment (mean)]*[Business Angel]

be challenged—i.e., which institutional descriptor should be used to weigh a given aggregate of individual-level data? As with any index, an element of arbitrariness may be introduced through the selection of some descriptors and not others. At the moment, no theory is specific enough to firmly guide weight selection. Furthermore, in practice, our choice has been constrained by limited data availability to cover the broad range of countries in our sample. Limited country coverage was the reason for omitting the World Bank new business registration data set, for example.

We addressed the weight selection challenge by choosing (from among available data) the institutional variables that seemed to provide the best match with received empirical and theoretical research on the specific aspect. We also tested numerous alternative weights before converging on the current ones. The selection criteria for institutional variables were: (1) logical link to the particular aggregate of individual-level data; (2) clear interpretation of the selected variable; and (3) avoidance of repetition: one weight was combined with only one aggregate of individual-level data. The institutional weights are shown in Table 2 and the resulting index pillars in Table 3.

Although the choice of variables and the index composition itself can and should be debated (different configurations may be appropriate for different levels of economic development, for example), we believe that the valuable aspect of contextualization provides a reasonable counter-balance towards this limitation. Next we address the question of component interactions and introduce a methodology to recognize systemic bottlenecks.

4.2. Addressing systemic interactions: the Penalty for Bottleneck

A fundamental, defining characteristic of systems is that they consist of components that *interact* to produce system performance. Most received indices are not systemic in this sense, as they do not allow index components to interact. Instead, received indices allow each component to create an *independent* contribution to the index total regardless of the value of other components. This means that system dynamics produced through component interactions are ignored.

To address this challenge, configuration theory provides a useful way forward (Miller, 1986, 1996). Configurations are defined as *"...represent(ing) a number of specific and separate attributes which are meaningful collectively rather than individually... configurations are finite in number and represent a unique, tightly integrated, and therefore relatively long-lived set of dynamics"* (Dess et al., 1993: 775–776). We introduce system dynamics into the GEDI index by allowing its constituent components to interact.

The notion of *bottlenecks* represents a direct corollary of the notion of components interacting to produce system performance. Two closely related theories, the theory of the weakest link (TWL) and the theory of constraints (TOC) argue that the performance of any dynamic system characterized by interdependencies and feedback loops depends on the element that has the lowest value in the system structure. According to the TOC, improvement can only be achieved by strengthening the weakest link – the bottleneck – that constrains the performance of the system (Goldratt, 1994; Tol and Yohe, 2006; Yohe and Tol, 2001). Put another way, the TWL maintains that the elements of the system are only partially substitutable with one another (Harrison and Hirshleifer, 1989). In the context of National Systems of Entrepreneurship, this means that if, say, education constitutes a bottleneck, this cannot easily be substituted for with increased provision of risk capital. Traditional index methods, being based on cumulative addition of independent index components, effectively assume full substitution and therefore cannot recognize or handle bottleneck effects.

While the TWL and TOC have mostly been applied to production and operations management, there are also a few applications in humanities and social sciences (Harrison and Hirshleifer, 1989; Rajan and Bird, 2001; Tol and Yohe, 2006).[2] According to the popular six sigma management theory, the improvement of the production process can be achieved by removing the causes of mistakes (weakest link) and decreasing variation in the system (Nave, 2002; Stamatis, 2004). The notion of constrains is also present in

[2] In a public choice paper Harrison and Hirshleifer (1989) present a model where the individual social composition function is constructed by taking into account the weakest link. The financial system can also be described by the weakest link postulate (Rajan and Bird, 2001).

Table 2
Description of the institutional variables used in the GEDI index.

Institutional variable	Description	Source of data	Data availability
Domestic market	Domestic market size is the sum of gross domestic product plus value of imports of goods and services, minus value of exports of goods and services, normalized on a 1–7 (best) scale. Data are from the World Economic Forum Competitiveness	World Economic Forum	The Global Competitiveness Report 2012–2013, p. 496
Urbanization	Urbanization is the percentage of the population living in urban areas. Data are from the Population Division of the United Nations, 2011	United Nations	http://data.worldbank.org
Market agglomeration	Market agglomeration is a combined measure of domestic market and urbanization: Calculated as [domestic market] × [urbanization]	Own calculation	
Tertiary education	Gross enrolment ratio in tertiary education. 2011 or latest available data	UNESCO	http://stats.uis.unesco.org
Business risk	The business climate rate "assesses the overall business environment quality in a country. . . It reflects whether corporate financial information is available and reliable, whether the legal system provides fair and efficient creditor protection, and whether a country's institutional framework is favorable to intercompany transactions" (http://www.trading-safely.com/). This is part of the Country Risk Rate. The alphabetical rating is converted to a seven-point scale from 1 ("D" rating) to 7 (A1 rating). Data from December 2012	Coface	http://www.coface.com
Internet usage	Number of Internet users in a particular country per 100 inhabitants, 2012 data	International Telecommunication Union	http://www.itu.int
Corruption	The Corruption Perceptions Index (CPI) measures the perceived level of public-sector corruption in a country. "The CPI is a "survey of surveys", based on 13 different expert and business surveys." (http://www.transparency.org). Overall performance is measured on a ten-point scale. Data are from 2012	Transparency International	http://cpi.transparency.org
Economic freedom	"Business freedom is a quantitative measure of the ability to start, operate, and close a business that represents the overall burden of regulation, as well as the efficiency of government in the regulatory process. The business freedom score for each country is a number between 0 and 100, with 100 equaling the freest business environment. The score is based on 10 factors, all weighted equally, using data from the World Bank's *Doing Business* study". (http://www.heritage.org). Data are from 2011	Heritage Foundation/World Bank	http://www.heritage.org
Gender equality	This is the female economic participation and opportunity sub-index, a part of the Gender Gap Index consisting of three parts: ". . .as the participation gap, the remuneration gap and the advancement gap. The participation gap is captured using the difference in labour force participation rates. The remuneration gap is captured through . . .the . . .ratio of estimated female-to-male earned income. . . and the gap between the advancement of women and men is . . .the ratio of women to men among legislators, senior officials and managers, and the ratio of women to men among technical and professional workers."	World Economic Forum	The Global Gender Gap Report 2012: pp. 10–11
Tech absorption	Firm-level technology absorption capability: "Companies in your country are (1 = not able to absorb new technology, 7 = aggressive in absorbing new technology)"	World Economic Forum	The Global Competitiveness Report 2012–2013: p. 489
Staff training	The extent of staff training: "To what extent do companies in your country invest in training and employee development? (1 = hardly at all; 7 = to a great extent)"	World Economic Forum	The Global Competitiveness Report 2012–2013: p. 447
Market dominance	Extent of market dominance: "Corporate activity in your country is (1 = dominated by a few business groups, 7 = spread among many firms)"	World Economic Forum	The Global Competitiveness Report 2012–2013: p. 451
Technology transfer	These are the innovation index points from the Global Competitiveness Index: a complex measure of innovation including investment in R&D by the private sector, the presence of high-quality scientific research institutions, collaboration in research between universities and industry, and the quality of protection of intellectual property	World Economic Forum	The Global Competitiveness Report 2012–2013: p. 20
GERD	Gross domestic expenditure on R&D (GERD) as a percentage of GDP, year 2011 or latest available data. The values for Puerto Rico, Dominican Republic, United Arab Emirates, and some African countries are estimated	UNESCO	http://stats.uis.unesco.org
Business strategy	Refers to the ability of companies to pursue distinctive strategies, which involves differentiated positioning and innovative means of production and service delivery	World Economic Forum	The Global Competitiveness Report 2012–2013: p. 20
Globalization	A part of the Globalization Index measuring the economic dimension of globalization. The variable involves the actual flows of trade, Foreign Direct Investment, portfolio investment and income payments to foreign nationals, as well as restrictions of hidden import barriers, mean tariff rate, taxes on international trade and capital account restrictions. Data are from the 2013 report and based on the 2010 survey. http://globalization.kof.ethz.ch/media/filer_public/2013/03/25/rankings_2013.pdf	KOF Swiss Economic Institute	Dreher, Axel (2006): Does Globalization Affect Growth? Evidence from a new Index of Globalization, *Applied Economics 38*, 10: 1091–1110
Depth of Capital Market	The Depth of Capital Market is one of the six sub-indices of the Venture Capital and Private Equity index. This variable is a complex measure of the size and liquidity of the stock market, level of IPO, M&A and debt and credit market activity. Note that there were some methodological changes over the 2006-2012 time period so comparison with previous years is not perfect. The data was helpfully provided by Alexander Groh*	EMLYON Business School, France and IESE Business School, Barcelona, Spain	Groh, A.H. Liechtenstein and K. Lieser, 2012. The Global Venture Capital and Private Equity Country Attractiveness Index 2012 Annual Report http://blog.iese.edu/vcpeindex

*We thank Alexander Groh and his team for providing the Depth of Capital Market data.

the institutional literature, where it is used to imply that economic development or growth depends on alleviating the binding institutional barriers (North, 1990). In our index building effort, we apply the same principle to capturing national entrepreneurial dynamics.

In our Penalty for Bottleneck (PFB) methodology, a bottleneck is defined as the weakest link or the binding constraint in the national entrepreneurial dynamic. Mathematically, a bottleneck is represented by the lowest value within a given set of normalized index

components. After normalizing the scores of all index components, the value of each component is 'penalized' by linking it to the score of the indicator with the weakest performance in a given country. This simulates the notion of a bottleneck: if the bottleneck component is alleviated, the particular sub-index and ultimately the entire GEDI index would show a significant improvement.

Generally speaking, the penalty for bottleneck should be larger if there are greater differences between components. From the configuration perspective, this implies that stable and efficient configurations are those that are balanced—i.e., that all component values are at the same level. Traditional index methods assume full substitutability between system components: a loss in one component can be fully compensated by a corresponding increase in another system component. This, however, is not a realistic portrayal of systemic phenomena, where the level of substitutability between individual components may vary. In our method, we assume an increasing rate of the Marginal Rate of Substitution meaning a higher compensation for the loss in one pillar if the difference between another pillar value and the particular pillar is larger (Tarabusi and Palazzi, 2004). The required positive value of the second derivative means that the pillars are only partially substitutable with one another.

Mathematically, we model the penalty for bottleneck following the approach proposed by Tarabusi and Palazzi (2004). They suggested a correction form of an exponential function of ae^{-bx}. Modifying Tarabusi and Palazzi (2004) original function for our purposes, we define a penalty function family as:

$$h_{(i),j} = \min y_{(i),j} + (1 - e^{-(y_{(i),j}) - \min y_{(i),j}}) \quad (1)$$

where $h_{(i),j}$ is the modified, post-penalty value of index component j in country i, $y_{i,j}$ the normalized value of index component j in country i and $y_{\min}$ is the lowest value of $y_{i,j}$ for country i. $i = 1, 2, \ldots, n$ = the number of countries, $j = 1, 2, \ldots, m$ = the number of index components.

The bottleneck is achieved for each indicator by adding one minus the base of the natural logarithm of the negative difference between a given index component's value in country i and the lowest normalized value of any index component for that country. Thus, improving the score of the weakest index component will have a greater effect on the index than will the act of improving the score of stronger index components. For example, assume that the normalized score of a particular index component in a country is 0.60, and the lowest value of all components is 0.40. The difference is 0.20. The base of natural logarithm of −0.2 is 0.82. Therefore, the final adjusted value of the index component is 0.40 + 1 − 0.82 = 0.58 instead of 0.60. The largest potential difference between two index components is 1, when a particular country exhibits the highest value for one index component (across all countries) and the lowest value for another index component, again across all countries. In this case, the maximum penalty is 0.37. It also means that the best indicator performance just compensates for the bad performance of the worst indicator by only 63%.

We suggest that this penalty for bottleneck approach is particularly useful for portraying the dynamic of National Systems of Entrepreneurship. There is a strong argument that entrepreneurship policy cannot be 'siloed', but rather, requires coordination across policy domains because of interdependencies that exist among policy actions (Audretsch, 2007; Autio et al., 2007). Traditional cumulative indices are unable to capture and appropriately account for such interdependencies. For example, if a given country exhibits very strong performance in some domains but very weak in others, traditional additive index methods would still represent the country's overall performance as average to strong. In the bottleneck approach, that country would be penalized more for its weaknesses, and its overall index score would be represented as weaker than average.

4.3. Addressing multi-faceted character of NES: index components

To address the multi-faceted character of NES, the proposed Global Entrepreneurship and Development Index (in brief, GEDI) consists of a total of fifteen components, called pillars. These are designed to capture entrepreneurial attitudes, ability, and aspirations. Of these, the attitudes and ability sub-indices are designed to introduce individual-level motivations and preferences into the index. Each of the components–or pillars, as we call them–is made up by national-level aggregates of individual data, weighted by data describing national institutional conditions.

The individual-level data is derived from the GEM survey, as published in annual GEM executive reports. The GEM follows sophisticated procedures to avoid sampling bias and ensure population representativeness (Reynolds et al., 2005). Randomized cluster sampling is primarily used, with appropriate adjustments in countries with poor telephony coverage and in countries with high levels of mobile phone use. Sophisticated weighting procedures are applied to allow population representativeness. However, while the sample size of at least 2000 individuals is used per country (with some countries conducting up to 30,000 interviews annually), this is still quite small for variables that measure relatively rare phenomena such as population density of high-growth entrepreneurs. So as to smooth out random fluctuations, we use two-year moving averages for all variables derived from the GEM data.

The institutional weighting variables are drawn from multiple sources, including Transparency International (Corruption Perception Index), UNESCO (Tertiary education enrollment, GERD), World Economic Forum (Domestic market size, Business sophistication, Gender equality, Innovation, Technology absorption capability, Staff training, Market dominance,), International Telecommunication Union (Internet usage), Heritage Foundation, World Bank (Economic freedom), United Nations (Urbanization index), KOF Swiss Economic Institute (Economic globalization), Groh et al. (2012) (Depth of Capital markets), and Coface (Business climate risk). The full description of the institutional variables, their sources and the year of survey are provided in Table 2. The national aggregates of individual-level data are listed in Table 1. The composition of the GEDI index and its sub-indices is given in Table 3. We provide a more detailed discussion of each of the fifteen pillars in Appendix 1.

All index components were formed as interactions between institutional descriptors and national aggregates of individual-level data. The Penalty for Bottleneck method was used to adjust the pillars for systemic effects, and the aggregate index is simply the average of the fifteen PFB-adjusted pillars. The following steps were followed when constructing the index:

1. Indicator values were first normalized to a range from 0 to 1. The most commonly used z-score, a mean of 0 and variance of 1 could be applied because the PFB method requires that all variables are in the same range. The *min–max* approach had the disadvantage of increasing the differences, even if real deviations are minimal. This is why we selected the distance normalization technique that preserves the distance (relative differences) amongst the countries:

$$x_{i,j} = \frac{z_{i,j}}{\max z_{i,j}} \quad (2)$$

for all $j = 1, \ldots, 15$, the number of pillars

Table 3
Countries included in the GEDI index and the calculation of individual variables (numbers indicate sample sizes).

Country	2006	2007	2008	2009	2010	2011	2012	Calculation*
Algeria						3373	4984	2011–2012 mean
Angola							2489	2012 data
Argentina						1687	1713	2011–2012 mean
Australia					1705	1622		2010–2011 mean
Austria							4548	2012 data
Bangladesh						1932		2011 data
Barbados						2186	2044	2011–2012 mean
Belgium						1839	1546	2011–2012 mean
Bolivia					3524			2010 data
Bosnia and Herzegovina						2277	2001	2011–2012 mean
Botswana							2003	2012 data
Brazil						1999	10,000	2011–2012 mean
Chile						6213	1952	2011–2012 mean
China						3689	3684	2011–2012 mean
Colombia						10,374	6471	2011–2012 mean
Costa Rica							2041	2012 data
Croatia						2000	2000	2011–2012 mean
Czech Republic						2005		2011 data
Denmark						2015	2217	2011–2012 mean
Dominican Republic				2007				2009 data
Ecuador							2003	2012 data
Egypt							2501	2012 data
El Salvador							1905	2012 data
Estonia							1721	2012 data
Ethiopia							3003	2012 data
Finland						2011	2038	2011–2012 mean
France						1607	3210	2011–2012 mean
Germany						4260	4297	2011–2012 mean
Ghana							2213	2012 data
Greece						2000	2000	2011–2012 mean
Guatemala					2280	2398		2010–2011 mean
Hong Kong				2000				2009 data
Hungary						2002	2000	2011–2012 mean
Iceland					1684			2010 data
India			2032					2008 data
Indonesia	2000							2006 data
Iran						3322	3178	2011–2012 mean
Ireland						2002	2000	2011–2012 mean
Israel							2005	2012 data
Italy							2000	2012 data
Jamaica					2287	2047		2010–2011 mean
Japan						2004	2010	2011–2012 mean
Jordan				2006				2009 data
Kazakhstan		2000						2007 data
Korea						2001	2000	2011–2012 mean
Latvia						2000	2000	2011–2012 mean
Lebanon				2000				2009 data
Lithuania						2003	2003	2011 data
Macedonia							2003	2012 data
Malawi							1847	2012 data
Malaysia						2053	2006	2011–2012 mean
Mexico						2511	2516	2011–2012 mean
Montenegro					2000			2010 data
Morocco				1500				2009 data
Namibia							1959	2012 data
Netherlands						2861	2887	2011–2012 mean
Nigeria						2056	2651	2011–2012 mean
Norway						2001	1999	2011–2012 mean
Pakistan						2002	2000	2011–2012 mean
Panama						2001	1998	2011–2012 mean
Peru						2010	2071	2011–2012 mean
Philippines	2000							2006 data
Poland						2000	2003	2011–2012 mean
Portugal						2011	2001	2011–2012 mean
Puerto Rico		1998						2008 data
Romania						1739	1710	2011–2012 mean
Russia						7500	3541	2011–2012 mean
Saudi Arabia					1957			2010 data
Serbia				1766				2009 data
Singapore						2000	2001	2011–2012 mean
Slovak Republic						2000	2000	2011–2012 mean
Slovenia						2009	2010	2011–2012 mean
South Africa						2724	2655	2011–2012 mean
Spain						17,500	21,900	2011–2012 mean
Sweden						2143	1740	2011–2012 mean

Table 3 (*Continued*)

Country	2006	2007	2008	2009	2010	2011	2012	Calculation*
Switzerland						1612	1587	2011–2012 mean
Taiwan						2012	2009	2011–2012 mean
Thailand						2000	3000	2011–2012 mean
Trinidad and Tobago						1813	1802	2011–2012 mean
Tunisia							2000	2012 data
Turkey						2401	2401	2011–2012 mean
Uganda							2343	2012 data
United Arab Emirates						3029		2011 data
United Kingdom						1650	1676	2011–2012 mean
United States						4699	4265	2011–2012 mean
Uruguay						1658	1627	2011–2012 mean
Venezuela						1888		2011 data
Zambia							2155	2012 data
Total	4000	3998	2032	11,279	15,437	154,751	184,143	375,640

Angola and Tunisia WEF institutional variables are from 2011 to 2012. Source: GEM surveys, 2006–2012.
*For enhanced stability, means of two consecutive years have been used where available.

where $x_{i,j}$ is the normalized score value for country i and pillar j, $z_{i,j}$ the original indicator value for country i and pillar j after capping and $\max z_{i,j}$ is the maximum value for indicator j.

2. The different averages of the normalized values of the indicators imply that reaching the same indicator values require different effort and resources. Higher average values for some components – e.g., Opportunity Startup – could mean that it is easier to reach as compared to a component with a lower average value—e.g., Process Innovation. Since we want to apply GEDI for public policy purposes, the additional resources for the same marginal improvement of the average indicator values should be the same for all indicators. Therefore, we need a transformation to equate the average values of the components:

$$\bar{x}_j = \frac{\sum_{i=1}^{n} x_{i,j}}{n} \quad \text{for all } j \tag{3}$$

We want to transform the $x_{i,j}$ values such that the potential values to be in the [0,1] range.

$$y_{i,j} = x_{i,j}^{k} \tag{4}$$

where k is the "strength of adjustment", the k-th moment of x_j is exactly the needed average, $\bar{y}_j$. We have to find the root of the following equation for k:

$$\sum_{i=1}^{n} x_{i,j}^{k} - n\bar{y}_i = 0 \tag{5}$$

It is easy to see based on previous conditions and derivatives that the function is decreasing and convex, which means it can be quickly solved using the well-known Newton-Raphson method with an initial guess of 0. After obtaining k, the computations are straightforward. Note that if

$$\bar{x}_j < \bar{y}_j \quad k < 1$$
$$\bar{x}_j = \bar{y}_j \quad k = 1$$
$$\bar{x}_j > \bar{y}_j \quad k > 1$$

that is k be thought of as the strength (and direction) of adjustment.

3. After these transformations, the PFB methodology was used to create indicator-adjusted PFB values.
4. The value of a sub-index for any country was then calculated as the arithmetic average of its PFB-adjusted pillars for that sub-index. The potential maximum value of the sub-indices was 1 and the potential minimum 0, which both reflect the relative position of a country for a particular index component.
5. Finally, the GEDI index was calculated as the simple arithmetic average of the three sub-indices and multiplied by 100 to get a 100 point scale. Since 100 represent the theoretical limit, the GEDI points can also be interpreted as a measure of efficiency of the entrepreneurship resources.

The GEM individual variables are explained in more detail in Appendix 1.

Some of the variables ('Opportunity Recognition', 'Skill Perception', 'Know Entrepreneurs', 'Career', and 'Business Angel') are density measures, calculated as the share or respondents (drawn from 18 to 64 year old population using randomized cluster techniques and population weighting) responding affirmatively to the question. The remaining variables describe nascent and new entrepreneurs, as measured by the GEM consortium. Nascent businesses are start-up attempts that have not paid salaries for anyone for longer than three months, whereas new businesses are start-ups who have not paid salaries for anyone for longer than 42 months.

Outliers are a frequent problem in any dataset. We addressed this problem using the capping method at the pillar level. The benchmarking value in each indicator case was selected as the 95% cutoff point by using the 2006–2012 full data set with 355 observations.

5. Empirical illustration: GEDI index rankings

We report the ranks of the 88 countries in terms of the GEDI and the three sub-indices using individual data for years 2006–2012 and institutional data for year 2011–2012. The calculation of the applied individual variables and years are presented in Table 3.

The values of the GEDI index are examined in comparison to other important, widely used indices. The index component values of the three sub-indices are also presented.

Table 4 ranks countries according to their GEDI index value. The maximum index value is 100 and minimum 0. For each country we also indicate the GDP per capita (PPP). Innovation-driven Nordic and Anglo-Saxon countries are in the front ranks. According to GEDI, the US is ranked as first, suggesting the highest national potential for entrepreneurship among the sample countries. The US is followed by Australia. Also Scandinavian countries are ranked high: Sweden, Denmark, Finland, Iceland, and Norway are each in top fifteen.

It is noteworthy that the top of the list is populated by high-income economies. This reflects the importance of the quality of

Table 4
GEDI 2012 country ranking.

Rank	Country	GDP PC	GEDI	Rank	Country	GDP PC	GEDI
1	United States	43,063	82.5	45	South Africa	9860	40.4
2	Australia	35,669	77.9	46	Montenegro	10,711	39.5
3	Sweden	35,134	73.7	47	Lebanon	12,592	38.9
4	Denmark	32,333	72.5	48	Barbados	17,564	38.5
5	Switzerland	39,344	70.9	49	Argentina	15,501	38.4
6	Taiwan	35,604	69.5	50	Mexico	12,617	38.2
7	Finland	31,810	69.3	51	Greece	20,922	37.8
8	Netherlands	36,599	69.0	52	Tunisia	8442	37.2
9	United Kingdom	32,723	68.6	53	Costa Rica	11,156	37.2
10	Singapore	53,266	67.9	54	Namibia	6453	36.8
11	Iceland	34,029	67.5	55	Macedonia	9323	36.2
12	France	29,819	67.2	56	Botswana	14,639	35.6
13	Belgium	32,649	66.5	57	Thailand	8459	35.5
14	Norway	47,547	65.1	58	Panama	14,320	34.8
15	Chile	15,848	65.1	59	Dominican Republic	8794	34.3
16	Germany	34,766	64.6	60	Indonesia	4272	34.3
17	Austria	36,259	64.0	61	Serbia	9683	34.0
18	Ireland	36,755	61.8	62	Russia	15,177	33.2
19	Puerto Rico	17,300	61.7	63	Jordan	5298	31.7
20	Israel	26,720	59.7	64	Nigeria	2294	31.6
21	Estonia	18,722	59.0	65	Jamaica	7839	31.4
22	Slovenia	24,320	52.7	66	India	3341	31.3
23	Colombia	9124	49.8	67	Bolivia	4552	31.1
24	Lithuania	18,776	49.6	68	El Salvador	6093	31.0
25	Poland	18,297	49.1	69	Kazakhstan	11,973	30.6
26	Latvia	15,946	48.4	70	Brazil	10,264	30.4
27	United Arab Emirates	42,293	48.3	71	Trinidad & Tobago	22,966	30.4
28	Portugal	20,962	46.9	72	Morocco	4475	29.5
29	Spain	26,545	46.9	73	Ecuador	8393	29.3
30	Korea	27,991	46.7	74	Algeria	7339	29.1
31	Hong Kong	44,770	46.6	75	Angola	5262	28.7
32	Slovakia	21,257	46.6	76	Philippines	3803	28.5
33	Japan	31,425	46.1	77	Zambia	1475	28.4
34	Uruguay	13,821	45.3	78	Bosnia and Herzegovina	7356	27.8
35	Turkey	13,737	44.7	79	Venezuela	11,613	26.4
36	Romania	11,443	44.6	80	Ghana	1765	26.3
37	Czech Republic	23,763	44.6	81	Egypt	5795	25.2
38	Hungary	17,033	44.5	82	Iran	10,462	24.2
39	Malaysia	14,775	44.1	83	Malawi	777	20.9
40	Saudi Arabia	21,430	43.5	84	Guatemala	4396	20.7
41	China	7958	41.6	85	Ethiopia	981	19.8
42	Peru	9429	41.3	86	Uganda	1165	19.3
43	Italy	26,328	40.9	87	Pakistan	2491	18.7
44	Croatia	16,148	40.9	88	Bangladesh	1623	13.8

Source: Per capita GDP in PPP 2012 or latest available data, in 2005 constant international dollars, World Bank (Hong Kong data is from IMF and Puerto Rico data is from CIA).

institutions for national entrepreneurial potential. For comparison, if raw start-up rates only were examined, the list would be topped by low-income countries.

5.1. Responsiveness of the index to bottleneck alleviation

How does a country improve their relative position at the national level? The notion of the Penalty for Bottleneck implies that if the weakest pillar is improved, the overall GEDI score should show significant enhancement relative to the bottleneck improvement.[3] From the public policy perspective, this suggests focusing on the weakest pillar, because this is where policy effort should produce the greatest system-level improvement.[4] In the GEDI methodology, the magnitude of the overall GEDI score improvement is subject to the following assumptions:

1. The improvement depends not only on the weakest pillar value but also on the differences between the weakest and the second weakest pillar values, the differences between the second and the third weakest pillar values, and so on. The largest improvement can be achieved if a country has only *one* weak pillar, and after the adjustment all pillars will have the same value (i.e., no bottlenecks remain).
2. Another question is whether the additional policy effort is distributed among several weaker pillars. If distribution is allowed, then the magnifying effect can be larger, depending on the conditions described in the previous point.
3. A different situation emerges if we allow optimization of the whole system at the cost of worsening the best performing pillar(s). The optimal solution is when all pillar values are the same and no bottlenecks remain.

To highlight GEDI index dynamics, we next illustrate two cases in which we have an additional resource of 0.1 pillar 'units' that can be used to improve (1) only one bottleneck pillar value by 0.1 units; (2) to improve two or more pillar values by a total combined

[3] Note that although the GEDI method inevitably highlights some pillar as the bottleneck, this does not mean that the pillar actually operates as a systemic bottleneck in reality. Whereas some pillars might actually operate as bottlenecks, other pillars might not. The GEDI analysis should always be complemented with detailed insight into the conditions of the country being analyzed. Our focus here is on the improvement of GEDI index *scores*.

[4] Note that bottlenecks implied by the GEDI analysis might not be true bottlenecks in reality. The existence of bottlenecks in reality should always be subject to further analysis with country-specific data—see Section 6.

amount of 0.1 units. In the second case, we would first alleviate the worst-performing pillars by a combined amount of 0.1 units. For simplicity, we assume that the cost of achieving the 0.1 unit improvement is the same for all pillars. We also disregard country size differences.

We use three countries as examples: US, Japan, and India. Table 5 shows: (1) the original normalized scores; (2) the PFB adjusted values; (3) the effect of improving only the weakest pillar by 0.1 units; and (4) the situation where the 0.1 unit improvement is divided amongst the two weakest pillars to optimize the improvement.

The United States, the highest-scoring country in our sample, has a relatively balanced performance profile over the fifteen components of their National System of Entrepreneurship, with individual pillar values ranging from 0.61 (Networking) to 1.0 (Opportunity Perception, Startup Skills, and Competition). A closer look reveals that four pillars have a value smaller than 0.8: Risk Acceptance (0.70), Networking (0.61), Opportunity Startup (0.75), and Internationalization (0.72).

We can see that if we increase the weakest pillar value (Networking) for the US by 0.1 units, a new bottleneck, Risk Acceptance emerges (see shift from column 2 to column 3). This produces an improvement of 2.2 index points in the overall GEDI index value for the US from 82.5 to 84.7 (i.e., a percentage increase of 2.65%). However, because of its relatively well balanced performance profile (meaning that all pillars perform relatively well), this improvement only produces a relatively small improvement in the overall GEDI index value for the US. To produce an optimal outcome (i.e., obtaining the greatest increase in the index value for the same effort), the 0.1 unit pillar improvement effort should be allocated amongst the two weakest pillars, Networking and Risk Acceptance (see column 4). This optimization produces an additional 0.1 index point increase in the GEDI index value for the US (i.e., 0.15%).

Japan's NSE pillar values exhibit an imbalanced profile, ranging from an extremely low level of Startup Skills (0.13) to a high level of the High Growth pillar (1.00). If we improve Japan's weakest bottleneck pillar by 0.1 units (Startup Skills), Opportunity Perception (0.18) becomes the weakest link in the system (see columns 2 and 3). Because Japan's profile is more imbalanced than that of the US, this produces an overall improvement of the GEDI index value of 2.1 index points (4.7%), i.e., a larger relative improvement than for the US. Because the difference between the two weakest pillars is relatively small, the 'optimal' distribution of the 0.1 unit improvement effort should be divided between Startup Skills and Opportunity Perception. An 'optimal' allocation of policy effort produces a further increase in Japan's GEDI score of 0.8 index units to 49.0—an additional improvement of 1.56% (i.e., 6.33–4.67, see column 4 in Table 5).

Our third country example, India has many bottlenecks. Improving its weakest pillar, Opportunity Startup (0.14) does not help too much, because Internationalization quickly becomes the binding constraint. So alleviating only Opportunity Perception increases India's GEDI score by only 2.1%. However, if the 0.1 pillar improvement effort is divided amongst Opportunity Perception (0.42), Internationalization (0.40) and the third bottleneck, High growth (0,18) then the GEDI score increases to 32.7, i.e., by 4.2%.

5.2. Comparing countries with GEDI

The most important benefit of the Penalty of Bottleneck method is that it draws attention to bottleneck factors that hold back system-level performance. In addition, the normalization process helps illustrate how much a given country could stand to improve its performance, if the bottleneck factor is alleviated. This feature can be illustrated using a baking analogy. The basic ingredients of a cake are flour (suppose one kilogram required), eggs (6 eggs required—i.e., 300 g of egg), and sugar (200 g required)—a total of 1500 g of ingredients. Now suppose we only have 100 g of sugar—a bottleneck ingredient. In a traditional index method, we now would have 1400 g of ingredients—a deterioration of some 9%. In contrast, the GEDI method recognizes sugar as a bottleneck factor, and 100 g of sugar only allows us to effectively use only 500 g of flour and 150 g of egg (3 eggs) – for a total of 750 g of ingredients – a deterioration of 50%, as opposed to 9%. Conversely, by only adding 100 more grams of sugar, we can now utilize all ingredients effectively, and we would get 1500 g (50%) more cake.

The illustration above is simplifying, as GEDI's Penalty for Bottleneck approach allows some substitutability between index components. The example nevertheless highlights the problem with the assumption of full substitutability between index components. This is an untenable assumption for a systemic phenomenon such as National Entrepreneurship. Because the Penalty for Bottleneck method helps draw attention to bottleneck factors, the GEDI index provides a potentially potent platform for the analysis of National Systems of Entrepreneurship, as well as for the design of policies geared to alleviating system-level bottlenecks. As an example, let us compare the three countries illustrated in Table 5—USA, Japan, and India. The index pillar values for the three countries are illustrated in Fig. 1.

As can be seen in Fig. 1, United States is clearly ahead of Japan and India for almost all pillars except for Process Innovation and High Growth where Japan leads. The two countries perform at the same level in the Quality of Human Resources pillar, Technology Sector pillar, and in Risk Acceptance. Another observation is that the overall profile of the US is relatively more balanced (i.e., rounder in the graph) than that of Japan or India—a feature that contributed to the relative insensitivity of the US towards the alleviation of bottlenecks.

Fig. 1 also immediately highlights the bottleneck features that constrain Japan's and India's performance. In the case of India, the key bottlenecks are Opportunity Startup and Internationalization as well as High Growth. For Japan, the bottlenecks are with Startup Skills and Opportunity Perception.

From a policy perspective, these observations yield potentially useful insight. First, in addition to highlighting bottleneck factors, the index values also indicate how much a country should seek to alleviate a given bottleneck. In the case of Japan, for example, the index suggests a bottleneck in Startup Skills. While this observation does not prove that a bottleneck exists, it nevertheless should prompt further investigation to determine whether the bottleneck is real. If further investigations support the existence of a bottleneck in this area, the index provides some indication as to how much Japan should aspire to improve its performance in this area. Similarly, the index suggests that Opportunity Perception is at an alarmingly low level in Japan. Should further inquiries support this conjecture, Japan might want to address the perception of Startup Skills, which likely would also improve Opportunity Perception. India, on the other hand, might want to explore whether the quality of its startups constitutes a real problem that requires further attention.

Although the Penalty for Bottleneck method does not *prove* the existence of bottlenecks, it may nevertheless be useful in pinpointing potential areas of relative weakness, and it may also prompt helpful investigations into how different elements of National Systems of Entrepreneurship interact. The existence of bottlenecks, as suggested by the GEDI analysis, should always be verified using additional data from the country in question. Whether or not such investigations confirm existence of a bottleneck, they would likely encourage a systemic and coordinated approach to entrepreneurship policy analysis and design.

In addition to highlighting bottlenecks, additional insight could be gained by comparing countries against relevant peers. Being at the same level of economic development, comparisons between

Table 5
Sensitivity of the GEDI index to bottleneck factors.

Country	USA				Japan				India			
GEDI index pillar	1	2	3	4	1	2	3	4	1	2	3	4
Opportunity perception	1.000	0.933	1.000	1.000	0.180	0.179	0.180	0.206	0.578	0.495	0.578	0.578
Startup skills	1.000	0.934	1.000	1.000	0.132	0.132	0.232	0.206	0.238	0.233	0.238	0.238
Risk acceptance	0.695	0.692	0.695	0.704	0.686	0.557	0.686	0.686	0.330	0.313	0.330	0.330
Networking	0.612	0.612	0.712	0.704	0.338	0.318	0.338	0.338	0.212	0.210	0.212	0.212
Cultural support	0.828	0.806	0.828	0.828	0.425	0.386	0.425	0.425	0.348	0.328	0.348	0.348
Opportunity startup	0.752	0.743	0.752	0.752	0.623	0.520	0.623	0.623	0.142	0.142	0.242	0.184
Technology sector	0.894	0.857	0.894	0.894	0.248	0.242	0.248	0.248	0.336	0.318	0.336	0.336
Gender	0.811	0.792	0.811	0.811	0.791	0.615	0.791	0.791	0.360	0.338	0.360	0.360
Quality of human resources	0.949	0.898	0.949	0.949	0.985	0.706	0.985	0.985	0.532	0.465	0.532	0.532
Competition	1.000	0.934	1.000	1.000	0.479	0.426	0.479	0.479	0.441	0.400	0.441	0.441
Product innovation	0.861	0.832	0.861	0.861	0.765	0.601	0.765	0.765	0.231	0.227	0.231	0.231
Process innovation	0.902	0.864	0.902	0.902	0.988	0.708	0.988	0.988	0.569	0.489	0.569	0.569
High growth	0.883	0.849	0.883	0.883	1.000	0.712	1.000	1.000	0.167	0.166	0.167	0.184
Internationalization	0.723	0.717	0.723	0.723	0.347	0.325	0.347	0.347	0.144	0.144	0.144	0.184
Risk capital	0.968	0.912	0.968	0.968	0.569	0.486	0.569	0.569	0.482	0.430	0.482	0.482
GEDI index score		82.5	84.7	84.8		46.1	48.2	49.0		31.3	32.0	32.7
Percentage improvement*			2.65%	2.80%			4.67%	6.33%			2.14%	4.24%

Column 1: Original normalized, averaged pillar values.
Column 2: PFB adjusted pillar values (pillar values penalized for bottleneck).
Column 3: The effect of a 0.1-unit increase in the bottleneck pillar value.
Column 4: Optimal solution obtained by dividing the 0.1-unit increase over lowest pillar values.
*Percentage improvement relative to PFB adjusted index score without bottleneck alleviation in Column 2.

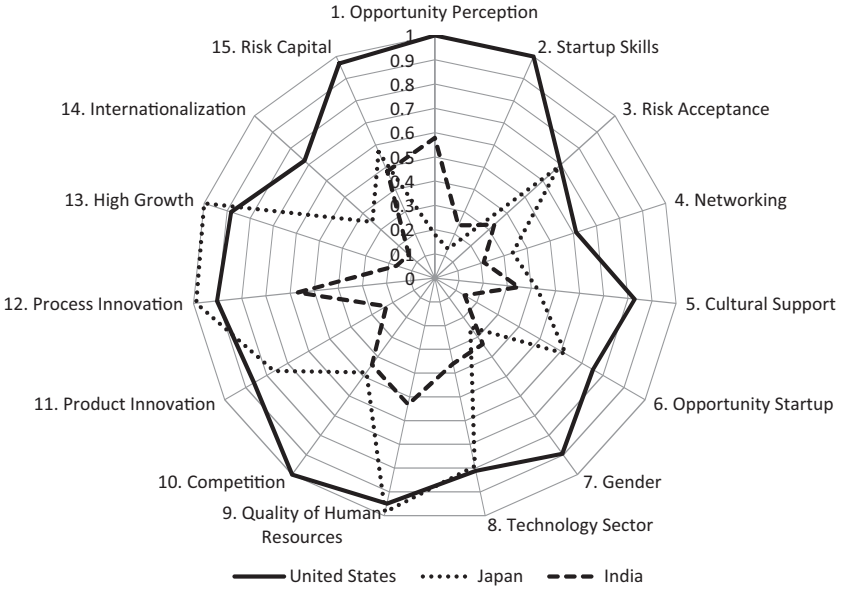

Fig. 1. GEDI comparison between US, Japan, and India (original normalized, average adjusted, non-penalized pillar values).

the US and Japan are likely more meaningful than between US and India, for example. In the case of US, comparisons against, say, Australia or EU countries might reveal interesting additional insight with regard to its relative strengths. Similarly, a comparison between China and India might illuminate addressable bottlenecks and strengths between those countries. Once potential suspects have been identified, they can be explored with additional data, appropriate metrics depending on the pillar in question. Parallel with this analysis, an inspection of specific policy measures in relevant peer countries might help identify policies that have worked elsewhere. A detailed inspection of such policy measures would then help illuminate transferable good practices that could be implemented within the country in question. Summarizing, the above discussion suggests the following heuristic for using the penalty of bottleneck approach for policy analysis, design, and implementation:

1. Identify bottleneck factors in the country's National System of Entrepreneurship and compare these against relevant peers (i.e., countries at a similar level of economic development, with similar demographic conditions and with similar levels of market size and market openness).
2. Examine the bottleneck factors more closely, complementing GEDI indicators with alternative proxies.
3. Conduct policy comparisons in bottleneck areas against relevant peers, with a focus on analyzing the anatomy of individual policy measures as well as identifying transferable good practices.
4. Design and implement policy programs designed to alleviate bottleneck factors in the country, using GEDI to help set targets for performance improvement.

It is essential to actively involve local policy-makers and policy stakeholders in the above process. Systems are complex, and

different system components may interact differently in different contexts. The PFB methodology makes two important restrictive assumptions: first, that the cost of improving pillar performance is the same for all pillars; and second, that all interactions between any two pillars are equally strong, implying the same bottleneck penalty for all pillars on the average. As an improvement of the original methodology, we have adjusted the average pillar values to the same level in order to make the marginal costs of improvement the same for all the 15 pillars. While this enhancement alleviates the first restrictive assumption, the second one continues to necessitate the input of country-specific data and insight. In addition, in some countries or regions, some system components may be more closely associated, and the cost of improving pillar performance may vary across countries. This means that local knowledge and intimate understanding of a given country is essential in making sense of GEDI country profiles. This also means that the GEDI analysis is not prescriptive. Ideally, the GEDI should be used as the *starting point* in policy analysis, in an interactive policy facilitation process that relies heavily on the input of local knowledge. Such input could be used to adjust bottleneck penalties for individual pairs of pillars, and also, assign different cost implications for different pillars. Used this way, GEDI could provide a powerful platform for a systemic approach to entrepreneurship policy analysis, design, and implementation, one that shifts focus from individual policy silos towards the National System of Entrepreneurship as a whole.

6. Discussion

Although the 'National Systems of Innovation' theory has gradually waned in popularity, both applied research and policy discussion around entrepreneurship appear to be assuming increasingly systemic hues (Autio et al., 2013b; Isenberg, 2010; Zacharakis et al., 2003). It is increasingly recognized that the 'heroic entrepreneur' is not the sole determinant of entrepreneurial success, and that the environment – or the 'ecosystem' – can play an important role in nurturing new venture seeds into fully-fledged, value-adding growth ventures (Autio and Thomas, 2013). However, in spite of the long-standing recognition of both systemic influences upon entrepreneurial action and systemic influences thereof (Autio, 1997), the entrepreneurship research tradition has failed to address country-level aspects of the entrepreneurial process.

In this paper we have sought to address the above gap by introducing the notion of National Systems of Entrepreneurship and proposing an index methodology to highlight interactions between components of NSEs that provides contextual grounding for entrepreneurial processes, as measured in entrepreneurship surveys, and helps explore bottlenecks that might hold back system performance. We reviewed received approaches to measuring and characterizing the workings and performance of NSEs and observed that while the different approaches all have their strengths, none of the received approaches has addressed the definition of NSEs head-on, and none of them is well suited to study the dynamic arising from interactions between the constituent components of NSEs. The Global Entrepreneurship and Development Index (GEDI) has been designed to address this gap.

In addition to introducing the concept of National Systems of Entrepreneurship, our main contribution is provided by an index-building methodology that: (1) helps contextualize national-level entrepreneurial processes, thereby making it relevant for the study of country-specific features; (2) incorporates interactions between system components, thereby reflecting the systemic characteristics of NSEs; (3) identifies bottleneck factors that hold back system performance, thereby drawing policy attention to system components that require most attention; (4) provides an idea of the sensitivity of system-level performance to bottleneck factors, thereby helping set tangible targets for policies and support initiatives designed to alleviate the bottleneck factors identified. Although this approach is not perfect (limitations will be highlighted below), the index method goes beyond received index methods, which tend to assume perfect substitutability between system components and therefore provide little guidance for policy design.

We think that our methodology offers important benefits for the analysis, design, and implementation of policies and support measures aimed at strengthening the entrepreneurial potential of individual countries. First, like national systems of innovation, country-level entrepreneurship clearly is a systemic phenomenon. What is needed, therefore, is a measurement approach that addresses the systemic character of NSEs head-on. To date, entrepreneurship policy design and implementation functions have tended to be confined to specific policy departments, with little or no coordination across policy silos. Such reductionist approaches can easily lead to sub-optimal policy frameworks that address surplus resources and ignore systemic constraints. By highlighting relative strengths and weaknesses, our methodology should help promote more balanced and better-coordinated entrepreneurship policy frameworks. Second, because our approach is based on normalized scores, it enables comparisons between constituent pillars of NSEs, as well as across countries. An important benefit of this normalization is that our method gives policy-makers an idea of how well their NSEs are performing relative to others, given their country-specific features. For example, our method provides the insight that, say, the USA's National System of Entrepreneurship currently operates at 82.5% of its theoretical maximum, within the confines of the NSE constituent pillars included in the GEDI index. Our methodology also provides the insight that if, say, Japan were to improve the performance of its Startup Skills and Opportunity Perception pillar by ten percentage points, its system-level performance (as reflected in the GEDI index) would improve by nearly three points. Analyses beyond GEDI (e.g., detailed policy comparisons against similar peers) could then be used to identify tangible policies to achieve this improvement—and also, give an idea of how much this performance improvement might cost. These are important insights that other index methods cannot offer. Third, because our methodology is agnostic with regard to data, it can be customized to address other systemic phenomena, such as National Systems of Innovation. We believe that, although research into NSIs has provided tremendous insight into what makes countries innovative, its potential to inform policy design has been held back by the absence of measurement methodologies that capture system dynamics. Therefore, the GEDI method should have applicability across a wide range of policy areas.

Summarizing, the GEDI design offers several important advances relative to received index methodologies. First, the construction of the pillars combines individual-level and institutional variables, thereby capturing the moderating effect of institutional conditions on individual-level processes. Thus, the institutional and environmental variables can also be interpreted as country-level weights of the individual-level data. Second, we created the first systemic index that meets with the requirements of the configuration theory. This approach is particularly useful in addressing the bottleneck problem of low performance of one or several constituent pillars and in focusing on the bottleneck that constitutes the weakest link amongst the pillars. This index building logic differs from other widely applied indexes in that it incorporates individual as well as institutional variables and takes into account the weakest link in the system. In practice, this means that the higher pillar values are adjusted to the weakest performing pillar value of the particular sub-index, thereby eliminating

full, one-to-one substitutability across pillars. While the exact measure of the penalty is unknown, meaning that the solution is not necessarily optimal, it still provides a better solution as compared to simply adding components into an overall summative index. Consequently, the methodology can be applied to problems where imperfect substitutability exists amongst constituent components of a wider system, and the efficiency of the system therefore is most heavily constrained by the weakest performing component.

In addition to its important benefits for policy practice, we believe that the GEDI method offers an important platform for future research in national-level entrepreneurship. To date, the link between 'entrepreneurship' and economic growth remains assumed rather than proven. Although there have been studies exploring this link (e.g., Wong et al., 2005), evidence remains inconclusive and anecdotal. We suggest that this is, in part, because of the multifaceted nature of the entrepreneurship phenomenon at the country level, and, in part, because received measures of country-level entrepreneurship have been either narrowly focused, de-contextualized, or de-coupled from actual individual-level entrepreneurial processes. The GEDI methodology addresses these shortcomings and should therefore provide a useful platform for future explorations that focus on the link between entrepreneurship and productivity.

Although we see many benefits in the GEDI methodology, there are also important limitations. First, when selecting the constituent pillars of the GEDI index we have been constrained by data availability and had to complement theoretical insight with iterative experimentation, because no detailed enough theory exists on country-level entrepreneurship. We therefore do not suggest that our selection of pillars is perfect or complete. In addition, the configuration theory implies that there may be several 'efficient' configurations from the systems perspective—i.e., that one perfect configuration may not exist that suits all countries and contexts. In this sense, our reduction of the fifteen pillar values into a single index value is simplifying. It is possible that different configurations may be needed, say, for countries at different levels of economic development. We therefore expect the GEDI index to be adjusted in the future, as data becomes available and our understanding of the phenomenon evolves.

Second, there is no theory or research to guide how the magnitude of the penalty should be set. This is why we applied a conservative estimation of the penalty. Comparing the correlations between the GDP per capita and the GEDI index calculated as the simple average of the indicators ($r = 0.89$) and the PFB methodology ($r = 0.88$) provides about the same correlation coefficient, with no statistically significant difference. Given that we are addressing a complex systemic phenomenon, we expect the eventual penalties to be gradually optimized in an iteration between different data that likely involves stochastic simulations.

Third, we have evoked the notion of component interactions 'producing' system performance, but we have not elaborated on the many different ways with which pillars may interact. For example, some pillars might operate as resource constraints—e.g., Finance. Other pillars could reinforce others, as could be the effect of Attitudes on Human Resources, for example. Yet other pillars could have a mutually reinforcing relationship, as could be the case of, say, the Product Innovation and Technology Sector pillars. The dynamics of such interactions are more complex than our PFB method has assumed and represent an interesting area of research on their own right.

Fourth, our context variables (as well as individual-level variables) have been limited to using available data. We do not claim that any of the pillars provides a full and complete insight into its theme. Therefore, we caution policy-makers not to take the picture provided by the GEDI method as the final truth, but rather, as a *starting point* that should trigger more detailed exploration into individual pillars, using a wide range of country-specific data that may not be available internationally.

Fifth, this version of the index focuses on countries. Evidently, in many countries there can be significant spatial variation in entrepreneurship across regions. The index version proposed here ignores such variation, although it is perfectly possible to build a regional GEDI index using regional data.

Finally, we caution policy-makers and researchers not to take the notion of bottlenecks too literally. Although the notion of bottleneck factors logically follows from the assumption of component interactions 'producing' system performance, the interactions are also more complex than portrayed in our model. As noted above, some pillars might operate more readily as bottlenecks than others—finance being a good example. Our main contribution here has been to highlight the possibility that the performance of NSEs may be subject to bottleneck constraints, but more conceptual and empirical research is needed to explore which pillars can operate as 'true' bottlenecks, under which conditions, and through which mechanisms.

These limitations notwithstanding, we hope that the GEDI index methodology will inspire future research and explorations into the, we believe, hitherto under-researched domain of National Systems of Entrepreneurship. During our investigations, we have identified several fruitful avenues for further research. First, we have repeatedly emphasized that systems are complex. Case studies are therefore important, not only to shed more light on the systemic interactions implied in the GEDI model, but also, identify causal mechanisms underlying (or not!) those interactions. We still know too little about the contributions of and constraints upon entrepreneurial action in different systemic contexts. This area cries out for further research. Second, our focus here has been on countries. As noted above, countries are not homogeneous, and regional systems of entrepreneurship might provide another useful focus for empirical research. Research on regions might provide an useful avenue for further research. Third, although we have argued for systemic characteristics of entrepreneurial processes, we have not provided a detailed discussion of interactions between individual pillars of systems of entrepreneurship. We hope that further research into such interactions will prove fruitful useful insight into how systems of entrepreneurship work. We hope that further research will help uncover such interactions.

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Appendix A. Appendix 1 Description of GEDI index pillars

The Opportunity Perception pillar captures opportunity perception – an essential precondition of entrepreneurial action (McMullen and Shepherd, 2006) – and combines it with the economic potential associated with those opportunities. Opportunity perception is measured as weighted percentage of the adult-age population perceiving good opportunities to start a new business (for GEM-based indicators, see Reynolds et al., 2005). The value of perceived opportunities depends on the size of the market. We therefore weigh this variable with two variables describing the domestic market: the size of the domestic market and the degree

of urbanization (combined here to reflect market agglomeration). Urbanization is used to capture the idea that opportunity pursuit is easier in urban areas, where customers tend to be closer and more affluent than in poorer rural areas

The Start-up Skills pillar captures the perception of start-up skills in the population and weights this aspect with the quality of human resources available for entrepreneurial processes in the country. Perceived self-efficacy is a major determinant of entrepreneurial action (Bandura, 1986), and action will be more effective, the higher the quality of human resources available for this action (Davidsson and Honig, 2003). We therefore weighted the start-up skills perceptions with the gross-enrollment ratio in tertiary education, as obtained from UNESCO statistics.

The Risk Acceptance pillar captures the important inhibiting effect of fear of failure on entrepreneurial action (Caliendo et al., 2009). It is measured as the weighted percentage (reversed) of the population who believe that fear of failure would prevent them from starting a business. As weight, we used a measure of business risk, which reflects the availability and reliability of corporate financial information, the protection of creditors by law, and the institutional support for inter-company transactions (see Table 2).

The Networking pillar provides a proxy of the ability of potential and active entrepreneurs to access and mobilize opportunities and resources. Networks are an important determinant of prospective entrepreneurs' resource acquisition ability (Uzzi, 1997; Yli-Renko et al., 2001) and the ability of entrepreneurs to discover opportunities (Ozgen and Baron, 2007). We operationalized the Networking pillar by weighting the population average of individuals who personally know at least one entrepreneur with the number of internet users per 100 inhabitants in the country. This weight captures the enhancing effect of the internet on social networking.

The Cultural Support pillar combines how positively a given country's inhabitants view entrepreneurs in term of status and career choice and how the level of corruption in that country affects this view. Cultural support regulates entrepreneurial action by influencing its perceived desirability (Ajzen, 1991; McMullen and Shepherd, 2006). High levels of corruption can undermine the perceived status of entrepreneurs and dampen entrepreneurial aspirations (Baumol, 1996; Dreher and Gassebner, 2007; Levie and Autio, 2011).

The Opportunity Startup pillar captures the prevalence of individuals who pursue opportunity-driven start-ups and weights this against regulatory constraints. An entrepreneur's motivation for starting a business is an important signal of new venture quality (McMullen et al., 2007). Opportunity entrepreneurs are believed to be better prepared, to have superior skills, and to generate more value than what we call necessity entrepreneurs (Levie and Autio, 2008). However, regulatory burden may inhibit this pursuit (Djankov et al., 2002). We used GEM's measure of the prevalence of opportunity start-ups and weighted this with the Heritage Foundation's Index of Economic Freedom.

The Gender pillar measures the accessibility of entrepreneurial opportunities for females, as compared to the male population. The Gender pillar is the combination of the percentage of women entrepreneurs in the TEA index (TEA female) and an institutional variable measuring female economic participation and opportunity (Gender Equality).

The Technology Sector pillar reflects the technology-intensity of a country's start-up activity. This measure provides an indication of the potential of start-up activity to drive productivity (Coad and Rao, 2008; Klepper, 2001). To form this pillar, we weighted the relative prevalence of technology-sector start-ups with a country's capacity for firm-level technology absorption, as reported by the World Economic Forum.

The Quality of Human Resources pillar captures the quality of entrepreneurs. It is widely held that entrepreneurs with higher education degrees are more capable and willing to start and manage high-growth businesses (Davidsson and Honig, 2003; Levie and Autio, 2008). This pillar was formed by weighing the percentage of start-ups founded by individuals with higher than secondary education with a qualitative measure of the propensity of firms in a given country to train their staff, as measured by the World Economic Forum.

The Competition pillar measures the level of the product or market uniqueness of start-ups (GEM weighted average), combined with the market power of existing businesses and business groups. The uniqueness aspect seeks to capture the Schumpeterian 'creative destruction' process (Schumpeter, 1996), whereas the market power aspect captures the degree to which incumbents are able to prevent entry and the rules of the game are distorted to favor incumbents (Caves and Porter, 1977).

The Product Innovation pillar captures the tendency of entrepreneurial firms to create new products and to adopt or imitate existing ones. This is another indicator of the potential of entrepreneurial firms to undermine incumbents and drive waves of creative destruction. This pillar was created by weighting the percentage of firms that offer products that are new to at least some of their customers (Reynolds et al., 2005) with a measure that combines private-sector R&D investment, the presence of high-quality research institutions, quality of technology transfer, and the protection of intellectual property.

The Process Innovation pillar captures the use of new technologies by start-ups. This is an important regulator of new firms' ability to add value (Deeds, 2001). To create this pillar, we combined the percentage of businesses whose principal underlying technology is less than five years old (Reynolds et al., 2005) with the Gross Domestic Expenditure on Research and Development (GERD), as reported by OECD. While R&D alone does not guarantee successful growth, it is clear that without systematic research activity, the development and the implementation of new technologies — and therefore future growth — will be inhibited (Stam and Wennberg, 2009).

The High Growth pillar is a combined measure of the percentage of high-growth businesses that intend to employ at least ten people and plan to grow more than 50 percent in five years and business strategy sophistication (Acs et al., 2009b). Business strategy sophistication refers to "the ability of companies to pursue distinctive strategies, which involves differentiated positioning and innovative means of production and service delivery". This measure was obtained from the World Economic Forum.

The Internationalization pillar captures the degree to which a country's entrepreneurs are internationalized, as measured by businesses' exporting potential. Internationalization is believed to be a major determinant of entrepreneurial firm growth (Clercq et al., 2005; Sapienza et al., 2006). To compute the pillar, this measure was weighted with the extent to which the country is economically globalized. This latter measure was obtained from KOF, the Swiss Economic Institute.

The Risk Capital pillar combines two measures of finance: informal investment in start-ups (Reynolds et al., 2005) and a measure of the availability of finance. The Depth of Capital Market is one of the six sub-indices of the Venture Capital and Private Equity Index (Groh et al., 2012). It is a complex measure of the size and liquidity of the stock market, level of IPO, M&A and debt and credit market activity. The development of the stock market and the liquidity of the M&A and IPO markets regulate venture capital exit opportunities. While the banking sector is considered to be less effective in financing startup businesses, the sub-index also measures the liquidity of debt and credit markets.

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