

An Assessment of Australia's Absorptive Capacity

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This report was commissioned by the Australian Government Department of Industry, Innovation, Science, Climate Change, Research and Tertiary Education with the overarching objective of contributing to knowing more about the impact of firm absorptive capacity on the extent and success of innovation. The specific goal of this report is to document the level of absorptive capacity across Australian firms and to identify the determinants and effects of absorptive capacity.

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Executive Summary

Research question

- Absorptive capacity is a summary measure of a firm's ability to recognize the value of external information, assimilate it, and apply it to useful (or profitable) ends. Having a large absorptive capacity means having a workforce with 'prepared minds'.
- This project estimates how absorptive capacity affects innovation performance in Australia using a survey of over 1400 firm observations.

Results

- Absorptive capacity is one of the major determinants of innovation (both the extent to which firms attempt to innovate and the extent to which they are successful in innovating). However, its effect is indirect. Absorptive capacity mainly operates via enhancing the organisation's internal capacity for generating new ideas.
- The most important factors associated with internal capacity are absorptive capacity and R&D expenditure, both of which are tightly coupled. In turn, the former is greatly related to the retention of valuable staff, staff attendance at conferences and other external events, and the degree of sophistication of the organisation's knowledge management system.

Empirical issues

- There is confusion in the empirical literature over how to measure the level, determinants, and effects of absorptive capacity. For example, some researchers use R&D expenditure to measure the level of absorptive capacity, others use R&D expenditure as a determinant of absorptive capacity and yet others use it to indicate the effects of absorptive capacity. This lack of consistency limits our ability to compare existing studies in a rigorous way.
- Given this, our empirical analysis devotes particular attention to deriving distinct measures of the various constructs: the level of absorptive capacity present in the organisation; the 'determinants' of absorptive capacity; and the 'effects' of absorptive capacity (noting that we are inferring determination and effects from statistical correlations)
- *Level*. Following revealed preference theory, the level of absorptive capacity is measured as how successful the firm has been in acquiring its new ideas and technologies from external sources. We also devise an analogous measure of how much capacity the firm has to generate new ideas and technologies from within itself.
- *Determinants*. Following the literature we test for the relative impacts of the organisations' stock of knowledge assets; current levels of R&D activity; their retention of valued staff; investments into staff training and their exposure to conferences and networking occasions; and the sophistication of their knowledge management systems.
- *Effects*. These are the extent and success of new-to-the-world and new-to-the-firm innovation.

Descriptive analysis

- Large firms are significantly more likely to report a higher level of absorptive capacity and internal capacity for learning about new products and processes than SMEs. Both large firms and SMEs reported that they learnt more from external sources than internal sources. This latter finding comes as no surprise since internal sources are limited while external sources are almost limitless.
- Large firms are more likely than SMEs to attempt both new-to-the-world and new-to-the-firm innovations. Both sectors, though, are considerably more likely to undertake new-to-the-firm innovations than new-to-the world innovations. As far as the success of these innovations is concerned, new-to-the firm innovations are more likely to be successful than new-to-the-world innovations, and large firms seem to be more successful than SMEs overall.
- Absorptive capacity (which is highly correlated with internal capacity) is higher the faster is the rate of product/service obsolescence; the faster is the rate of change in the product/service; the greater are the barriers to entry to the organisation's market; the more concentrated is the industry; and the lower is staff turnover.

Analytic results

- The main determinants of the level of absorptive capacity were (in rank order): the extent to which employees are encouraged to attend conferences and undertake secondments; the sophistication of the organisation's knowledge management system; R&D expenditure; and the stock of knowledge assets derived from professional and other non-managerial employees.
- The level of internal capacity was statistically associated with the level of absorptive capacity; the stock of knowledge assets derived from professional specialist employees; R&D expenditure; the extent to which the organisation provides formal training for employees; the extent to which employees are encouraged to attend conferences and undertake secondments; and the sophistication of the organisation's knowledge management system. Over and above absorptive capacity; internal capacity was influenced by the provision of formal training for employees.
- The extent of innovation performed and its success in the market place were heavily influenced by the level of internal capacity. Except for the extent of new-to-the-firm innovation, the level of absorptive capacity did not have a direct effect.

Note

- A list of definition of technical terms and acronyms is provided in Appendix C.

1. Introduction

This report updates our understanding of firm-level and sector-level absorptive capacity in the Australian economy. The need for this report stems from the limited literature available on Australian firms as well as an inconsistency in the measurement of absorptive capacity across studies. As we explain below, scholars use similar variables to measure distinct aspects of absorptive capacity: the size of its presence, or level, in the organisation; its determinants; and its effects. This lack of consistency limits our ability to compare existing studies in a scientifically rigorous way. Other authors have attempted such an analysis for the Australian economy. See, in particular, the excellent work by Scott-Kemmis et al. (2007).

The approach taken in this report is of a different nature. It involves two aspects. First, we review the recent literature for Australia. References from the literature are used to guide our empirical analysis by illustrating the determinants and effects of absorptive capacity. Second, we designed a firm-level survey to answer the following research question:¹

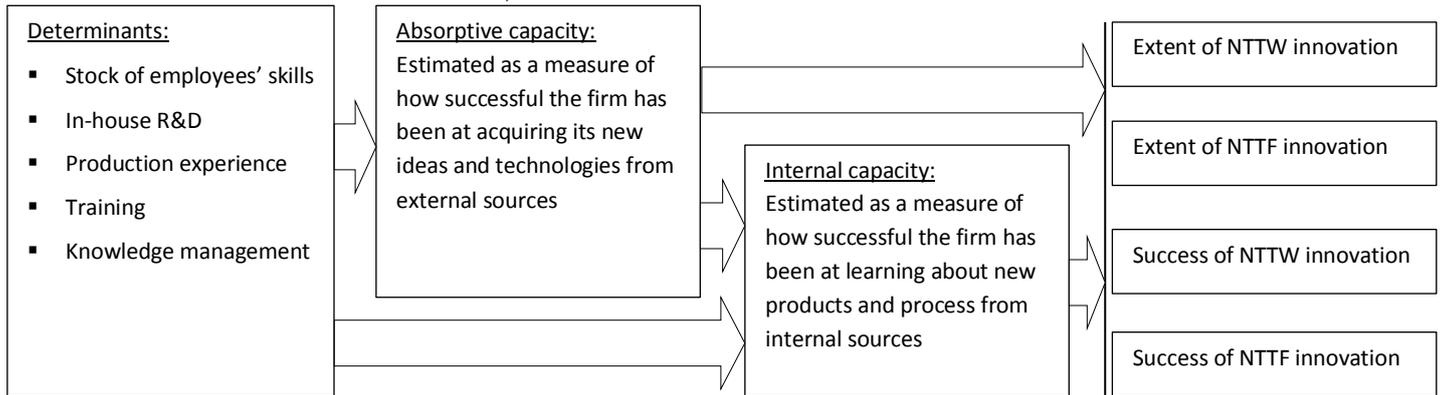
“What dimensions of firm absorptive capacity affect the strength of knowledge uptake, where strength in this context is reflected in higher productivity or more successful innovation?”

In performing the empirical analysis, we devote particular attention to the measurement of the various constructs. These constructs are: the level of absorptive capacity; the determinants of absorptive capacity; and the effects of absorptive capacity. We use revealed preference theory to devise a measure of the *level* of absorptive capacity. Specifically, we use survey questions on how successful the firm has been in acquiring its new ideas and technologies from external sources to reveal how much capacity it has to absorb these ideas. We also put forward a measure of internal innovation capacity, capturing the extent to which firms learn about new products and processes from internal routines such as reverse engineering. While there are no truly internal or external capacities, these concepts are useful to look for policy opportunities to increase the rate and scale of innovation in Australia. Regarding the *determinants* of absorptive capacity, we use the stock of employees’ skills as well as four augmenting factors: the amount of in-house R&D activity; production experience (accumulated learning-by-doing knowledge); training (formal staff training and staff attendance at conferences, seminars and networking occasions); and knowledge management. For the *effects* of absorptive capacity, we have two measures of the extent of innovation (extent to which the organisation has, over the past three years, introduced new-to-the world and new-to-the-firm innovations) as well as a more final measure on how successful the organisation is as an innovator (captured by questions reporting success, such as whether the innovation has proven successful on the market). A diagram of the empirical analysis is presented in Figure 1.

¹ The specific survey questionnaire can be obtained from the authors. See also Table B1 in Appendix B.

FIGURE 1: DIAGRAM OF EMPIRICAL ANALYSIS

Note: NTTW stands for new-to-the-world; NTTF stands for new-to-the-firm. See section 5.1 for details of constructs.



We also use our data to document differences in the level and the determinants of absorptive capacity between SMEs and large organisations, as well as to document how the level of absorptive capacity is affected by a range of environment variables.

The rest of the report is organised as follows. Section 2 provides key background information on absorptive capacity. Sections 3 and 4 review the recent Australian literature on the determinants and effects of absorptive capacity. Section 5 presents the empirical analysis. Finally, Section 6 summarises the results and puts forward policy implications.

2. Definition of absorptive capacity

Absorptive capacity is a firm’s ability to recognize the value of external information, assimilate it, and apply it to useful (or profitable) ends. Having a large absorptive capacity means having a workforce with ‘prepared minds’. The term ‘absorptive capacity’ was originally coined by Cohen and Levinthal (1990), but the origin of the concept can be traced to Arrow (1969), Varcoe (1974) and Caves and Uekusa (1976).² Formally articulating the role of ‘prepared minds’ occurred as theorists saw that many organisations did not exploit common knowledge because they were not able to translate its relevance to their own organisation.³ That is, people inside the organisation were not able to make the connections between their own innovation capabilities and what others knew and were doing. Expressed positively, organisations with a greater absorptive capacity saw further, and were the first to make conceptual linkages that allowed their organisations to make breakthroughs in new ideas and ways of doing things (Cohen and Levinthal 1990).

Scholars have looked at absorptive capacity from different angles and by using different lenses: theoretical development, cases studies and large-scale empirical analysis in neoclassical economics, evolutionary economics, and business strategy. This heterogeneity of approaches has produced a rich body of literature which confirms the important role of absorptive capacity in enhancing firms’ innovation performance and productivity (e.g. see the recent work by Scott-Kemmis et al. 2007). Absorptive capacity is also central to the diffusion of innovation in an innovation system: knowledge diffusion requires the ability to absorb external knowledge. Finally, it becomes an ever more important

² See the discussion in Mowery and Rosenberg (1991) and Mowery (1983).

³ Louis Pasteur said ‘Chance favours only the prepared mind’. By this he meant that sudden flashes of insight do not just happen, they are the products of preparation.

capability in an environment characterised by a global and open innovation process (Chesbrough 2003). All these reasons make absorptive capacity an important research topic that is also on the radar of policy makers.

Unfortunately the heterogeneity in approaches has also led to confusion in concepts and a lack of consistency across studies. One example is the confusion between the measures of absorptive capacity, the determinants of absorptive capacity and the effects of absorptive capacity. For instance, whereas some researchers use R&D expenditure to measure absorptive capacity (Kneller and Stevens 2006; Lane et al. 2006; Scott-Kemmis et al. 2007:14), others use R&D expenditure as a determinant or effect of absorptive capacity (Veugelers 1997; Mahmood and Lee 2004; Huang and Rice 2009). Human capital (i.e. the 'stock' of knowledge embedded in employees) is also subject to the same confusion. Although it is sometimes used as a measure of the level of absorptive capacity (e.g. Kneller and Stevens 2006), it is arguably a determinant: the higher the quality and the larger the human capital, the more the opportunities for learning and absorbing external knowledge.

In this report, we adopt the view that R&D expenditure and human capital are neither level nor effects variable but rather determinants of absorptive capacity. Following the logic of revealed preference theory, we measure the level of absorptive capacity as the extent to which firms learn (i.e. acquire information and knowledge) from outside sources. Human capital and R&D expenditure data, together with other variables, are factors affecting the opportunities for learning (and, therefore, are determinants of absorptive capacity). The rationale being that human capital and R&D expenditure capture both the size of the research team and the quality of the research environment, which affect an organisation's learning opportunities.

In our empirical work below, we make a clear distinction between the determinants and the effects of absorptive capacity in firms (Section 3 and 4, respectively). We introduce our learning-based measure of absorptive capacity in the empirical section (Section 5).

3. Determinants of absorptive capacity

The determinants of absorptive capacity under a narrow view comprise the skills and knowledge of an organisation's workforce, but broader and more popular explanations also embrace the firm's routines and processes that allow it to analyse, process, then act upon external information (Moreira and Markus 2013). In this latter sense, the whole is different from the sum of the parts. Having a large absorptive capacity means employing a high proportion of the workforce who are receptive to external ideas and adopting a management system that supports knowledge absorption. Whereas the foundation of a firm's absorptive capacity is the stock of employee skills, additional factors may affect how well these skills are deployed into productive ends. These additional factors include:

- *The amount of in-house R&D activity.* Lane et al. (2006) reviewed almost 300 papers that cite Cohen and Levinthal (1990) in the period up to mid-2002. They find that much of the literature identifies absorptive capacity with the knowledge base of the firm, and that investment in R&D is the most commonly used measure of the knowledge base (see Tsai 2001 for an illustrative example). The more a firm invests in R&D, the more it will be able to fully

appreciate the value of new external information, making R&D activity one of the most important determinants of absorptive capacity.

- *Production experience.* A great deal of learning is the result of day-to-day production, interaction and problem solving (see Lazonick 2005 for a review). Accumulated learning-by-doing knowledge enables employees to recognise and implement incremental methods to improve production processes.
- *Training.* This involves formal staff training and staff attendance at conferences, seminars and networking occasions, *inter alia*. Training encompasses activities that lead staff to be exposed to ideas outside the organisation. It includes both formal staff training and staff attendance at conferences and other networking occasions. The argument here is that the more exposure employees have to external ideas via training, the more they keep pace with the external development of knowledge (Daghfous 2004; Graca et al. 2005; Knudsen et al. 2001).

There is limited Australian empirical literature on the role of training investments in determining the size of firms' absorptive capacity. An exception is Toner and Dalitz (2012) who argue that the vocational education and training (VET) system plays a critical role in raising the absorptive capacity of the Australian workforce by imparting practical skills and underpinning knowledge. Because Australian firms have a low share of R&D to production and a disproportionately low–medium technology manufacturing industry, they are more reliant on VET skills to implement innovation compared to many other OECD nations. The dominant form of innovation in Australia is incremental and orientated to the adoption and adaptation of products, processes and services developed locally by other firms and industries or sourced from overseas (Hendrickson, Balaguer, et al. 2011, Chapter 1). Toner and Dalitz make the point that the VET system is largely excluded from government innovation policy and programmes in Australia which, they argue, is detrimental to the absorptive capacity of firms.

- *Collaborations.* Collaborations are another way in which employees can update their knowledge about the frontier of technology, costs and market demands. Together with training, collaborations constitute the external links of an organisation. Freeman and Soete (1997) provide evidence that more innovative and dynamic firms have more external links. Although training mostly implies passive staff involvement and loose links between actors, collaboration implies active involvement and close links. In Australia, Torugsa and Arundel (2012) use data for 1086 firms to study the effect of collaboration with public research organisations (PROs) on firm innovation as measured with the share of new product sales. They find an indirect association between collaboration with PROs and firm innovation performance. The impact of R&D and training investments on firms' innovation performance is enhanced by PRO collaboration, suggesting that training is an essential contingency for R&D to yield effective exploitation of private–public collaboration.
- *Knowledge management.* The sensitivity and sophistication of a firm's routines and processes that allow employees to retain knowledge and use it productively (analyse, process, then act upon) has been shown to affect firms' absorptive capacity (Van den Bosch et al. 1999; Lane and Lubatkin 1998, Moreira and Markus 2013). For example, Daghfous (2004) stresses the role that organisational culture can play in providing incentives for knowledge sharing. In

Australia, Soo et al. (2012) have investigated the role of intellectual capital enhancing human resources (HR) practices in the development of a firm's absorptive capacity. Intellectual capital includes human, social and organisational capital. The authors distinguish between potential and realised absorptive capacity following Zahra and George (2002), who explain that the firm's ability to realize performance improvements from external knowledge sources involves four distinct but complementary learning capabilities: acquisition (the ability to identify and acquire critical knowledge), assimilation (the ability to analyse, process, interpret and understand external knowledge), transformation (the ability to combine new and existing knowledge to gain new insights and perspectives), and exploitation (the ability to incorporate the newly acquired and transformed knowledge into the firm's operations). Using our nomenclature, we call 'potential absorptive capacity', just absorptive capacity, and 'realized absorptive capacity', the effects of absorptive capacity. Using survey data from 221 firms, Soo et al. (2012) find the following are positively related to potential absorptive capacity: (i) human capital enhancing HR (acquisition and developmental HR); (ii) social capital enhancing HR; (iii) collaborative practices; and (iv) organisation capital enhancing HR practices.

The literature sometimes distinguishes between different types of absorptive capacity, suited to different tasks of the innovation process. For example, Newey (2010) documents a longitudinal case study of the development of a ground-breaking anti-influenza drug throughout the innovation process (from idea to market launch). The initial discovery is owed to two Australian scientists and the case is thus an interesting story of how academic research translates into a successful product. This case provides insight on supplier- versus customer-types of absorptive capacity. Supplier absorptive capacity is defined as the absorptive capacity required while acting as a supplier and likewise for customer absorptive capacity. Newey comes to the conclusion that in-bound open innovation (bringing knowledge in) involves customer absorptive capacity whereas out-bound innovation (distributing knowledge out) requires supplier absorptive capacity. In this report, we consider only one general type of absorptive capacity. This choice is motivated by the large-scale analysis performed (which prevents us from digging too much into the details) as well as by the tradition in the field (the vast majority of studies consider a generic absorptive capacity).

The above discussion leads to the hypothesis that the degree of absorptive capacity held by each firm is a function of the level of in-house R&D; employee employment tenure; formal staff training; attendance at conferences and networking events; collaborations; and the sophistication of their knowledge management systems.

4. Effects of absorptive capacity

Absorptive capacity has been seen as a key contributor to a wide range of organisational outcomes (Van den Bosch et al. 2003, cited in Scott-Kemmis et al. 2007) including:

- innovative performance and new product development;

- competitive advantage, financial performance, transfer of best practices, knowledge flows within the firm and knowledge transfers;
- expectation formation, proactive strategy, strategic renewal, diversification and organisational adaptation;
- organisational learning in alliances and international joint venture performance; and
- new wealth creation and entrepreneurial wealth.

There is a limited Australian literature on the effectiveness of more absorptive capacity on innovation performance. Huang and Rice (2009) estimate the effect of open innovation practices on innovation performance (measured as R&D intensity) and in particular examine how this effect is mediated by the extent of the firm's absorptive capacity. However, R&D intensity includes both new-to-the-firm and new-to-the-world innovations and we would expect absorptive capacity to impact differentially on these two types of innovation.⁴ Huang and Rice use data from 292 innovating firms to construct two measures of open innovation: the degree of networking (measured by responses to survey questions relating to whether the firm has engaged in any formal networking with other firms in 1997–98); and the degree of technology buy-in (calculated by dividing the total expenditure on the development of new products and processes by the value of patents, trademarks and licences acquired in 1997–98).⁵ They measure absorptive capacity using data on investment in training. This is probably one of the narrower measures of absorptive capacity in the literature and one we would argue is a determinant, not a measure, of absorptive capacity. They find only a weak positive impact of networking on innovation performance and a negative relationship between technology buy-in and innovation performance. However, they find significant interaction effects between open innovation strategies and absorptive capacity (i.e. spending on training) in raising R&D intensity. Thus, investment in training plays an essential role in strengthening the positive effect of certain modes of openness such as networking and technology buy-in.

Bucic and Ngo (2012) study the influence of absorptive capacity on in-bound open innovation activities using a sample of 224 medium to large Australian firms. They show that absorptive capacity affects 'collaborative learning' (learning obtained through the evaluation of ideas, acquisition of information, and production of knowledge that has been generated by and evolves within the collaboration), which is itself an important determinant of open innovation. Note that we would use collaborative learning as a measure, not an effect, of absorptive capacity.

Whereas most studies focus on the capacity to absorb knowledge that is external to the firm (i.e. knowledge generated in collaboration with suppliers or customers), Schleimer and Pedersen (2013) consider the capacity of subsidiary firms to absorb knowledge generated *within* their multinational corporations (MNCs). Their study looks at the absorption of marketing strategies (an activity at the far end of the innovation process) of 213 Australian subsidiaries that are initiated by the overseas MNC parent. In particular, they investigate what specific organizational mechanisms are conducive for absorption. They find that specific organizational mechanisms (decentralization, normative integration, innovative culture) foster the subsidiaries' capacity to absorb parent-initiated marketing

⁴ Furthermore, this illustrates the measurement issues. Is R&D activity a determinant, effect or measure of absorptive capacity? Again, we adopt the view that R&D expenditure is a determinant of absorptive capacity.

⁵ The firms are Australian manufacturing SMEs that were active innovators and had continuous operations during the period 1994–1998 (ABS Business Longitudinal Survey).

strategies. Absorption is measured from three constructs related to value recognition (the subsidiary manager's ability to recognise and understand the benefits, components and importance of the marketing strategy), assimilation (extent to which the subsidiary manager was able to understand how the strategy could be successfully applied at the subsidiary level), and application (whether the subsidiary was able to apply the assimilated marketing strategy in the focal context and whether it was able to find ways to better exploit the strategy on an on-going basis after its integration).

Kraatz and Hampson (2013) consider the role of innovation brokers to enhance absorptive capacity. The case of the Australian Cooperative Research Centre for Construction Innovation (CRC-CI) is considered in the context of motivating supply chain firms to improve their organizational capabilities in order to acquire, assimilate, transfer and exploit R&D outcomes to their advantage. They illustrate the role of the CRC-CI in contributing to growth in the absorptive capacity of the Australian construction industry as a whole through two programmes: digital modelling/building information modelling (BIM) and construction site safety. The authors report numerous positive outcomes in productivity, quality, improved safety and competitiveness achieved over the period of study (2001 and 2009).⁶ In a similar vein, Couchman and Beckett (2009) explore 'R&D clubs' as an organizational initiative that addresses the issue of the limited absorptive capacity of Australian small firms. R&D clubs are focused networks formed between independent organizations in order to cooperate in the performance of R&D. The authors argue that such clubs help develop innovation capability within small firms. However, the evidence from both these studies is largely anecdotal.

Chalmers and Balan-Vnuk (2012) look at the means by which 14 not-for-profit innovative ventures in Australia and the UK develop the necessary capabilities to innovate. They find that these organisations combine 'sticky' context-specific user knowledge and complex forms of technological knowledge. The diverse stakeholder map, mission-driven goals and other organisational antecedents that characterise social organisations are shown to play an important role in the way that absorptive capacity is developed and exploited. The authors assess absorptive capacity in an informal manner by studying the extent to which organisations support and encourage the emergence of new ideas from within the organisation.

In the empirical analysis we will reduce these various outcomes to 'successful innovation'. There are two main types of innovations: new-to-the-world and new-to-the-firm innovations. Overwhelmingly, most innovations are new-to-the-firm and the dominant source of productivity growth is new-to-the-firm innovations. We expect that firms that engage in new-to-the-world innovations also engage in many innovations that imitate and copy other firms. However, the dominant view, based more on casual empiricism than hard data, is that the high income countries typically operate close to the new-to-the-world innovation frontier.⁷

5. Melbourne Institute survey of Australian firms

Despite the international recognition of the importance of absorptive capacity in innovation supply chains, Australian scholarship on this issue is in its infancy. There is very little systematic firm-level

⁶ See also Kraatz et al. (2012) for additional information.

⁷ Australia is a notable exception. Hendrickson, Balaguer, et al. (2011) note that the majority of Australian firms are adopting or modifying already existing innovations rather than creating world-first innovations.

information on the degree of absorptive capacity in Australia and even less empirical analysis on what aspect of the knowledge base gives the most efficient form of knowledge absorption.

Accordingly, in January to March 2013, we conducted a dedicated survey (the DIICSRTE/Melbourne Institute survey) to collect potential measures of absorptive capacity in order to test empirically which aspects of the knowledge base have most effect on the absorption of external knowledge. The data collected during this period is referred to as survey year '2012'. The survey questionnaire used was an adaptation of an existing large firm survey undertaken by the Melbourne Institute which is orientated around business environment, HR, innovation and management issues. The responses to most questions are in the form of a 7-point Likert scale, with the anchors 1='Not at all' or 'Not used at all' and 7='A very great extent' or 'All'. Only 62 completed questionnaires were received from large organisations in 2012.

The same questionnaire was sent to a stratified sample of randomly selected small and medium-sized enterprises (SMEs) from telephone listings from the year 2010. The sample was stratified by 1-digit industry. SMEs were contacted by telephone in the first instance to request their participation and to verify their contact details and employee size.⁸ Overall 639 firms agreed to participate and were sent a survey and reply-paid envelope, as well as a \$20 Coles–Myer voucher. Completed responses were received by 315 firms. While the original questions were targeted at large firms with HR departments, we retained the exact wording survey to enable us to pool the observations. For questions that relate mainly to large internal labour markets, the SME response will be 'Not at all'. Details of how the survey was conducted are described in Appendix A.

Table 1 below gives a summary of the numbers of completed survey responses.

TABLE 1. COMPLETED SURVEY RESPONSES 2004 TO 2012

	Large organisations	SMEs	Total
Completed surveys	1,457	315	1772
Distinct organisations	861	315	1176

Note: SMEs were surveyed in 2012 only.

As discussed above, in defining and measuring our concepts it is critical to distinguish between:

- the level of absorptive capacity;
- the determinants of absorptive capacity; and
- the effects of absorptive capacity.

Level. We use revealed preference theory to devise a measure of the level of absorptive capacity. Specifically, we use survey questions on how successful the firm has been in acquiring its new ideas and technologies from external sources to reveal how much capacity it has to absorb these ideas. To complement this measure, we also devise an analogous measure of how much capacity the firm has to generate new ideas and technologies from within itself.

Determinants. Following the literature, we will test the hypothesis that the degree of absorptive capacity held by each firm is a function of the its stock of knowledge assets; current levels of R&D

⁸ SMEs were defined as having less than 200 employed persons.

activity; its retention of valued staff; investments into staff training and its exposure to conferences and networking occasions; and the sophistication of its knowledge management systems. Ideally, we would include a measure of collaboration, however our survey does not have this indicator.

Effects. Finally, we test the hypothesis that absorptive capacity affects both the extent and success of innovation. We specifically distinguish between new-to-the-world and new-to-the-firm innovations. We expect that the relationship between absorptive capacity and new-to-the-firm innovation will be more pronounced than the relationship between absorptive capacity and new-to-the-world innovation because new-to-the-firm innovations depend heavily on external knowledge.⁹

5.1 Measuring our concepts

Level. As explained above, we measure the level of absorptive capacity as the extent to which firms are able to acquire information and knowledge (i.e. to learn) from external sources. Crowley (2004) documents various such sources of learning for European firms, including but not limited to learning from customers (roughly 30 per cent of firms rated this source as highly important), suppliers (20 per cent), and fairs and exhibitions (15 per cent). Accordingly, our actual measure of the degree of absorptive capacity, *AbsorptiveCapacity*, is a mean of 10 survey questions on the extent to which the organisation learns about new products and processes from: licensing technologies (both other firms, universities or research consortia); patent disclosures; publications or technical meetings; informal networks with other organisations; formal cooperation or networks with other organisations; lead customers; and suppliers. Note that our measure captures the potential absorptive capacity — the ability to acquire and assimilate knowledge (Zahra and George 2002). The realized absorptive capacity, for its part, is equivalent to our measure of the effects of absorptive capacity.

New ideas and technologies are also generated from within the organisation via the skills and capabilities of its own employees. Similar to the concept of the boundary of the firm, the line between internal generation and external acquisition can be more apparent than real. Hiring a former external collaborator can make external knowledge internal in an instant. However, for comparative reasons we need a measure of the organisation's capacity to generate new ideas from within itself. Hence we define a measure of the extent of internal (learning) capacity, *InternalCapacity*, as the mean of five survey questions on the extent to which the organisation learns about new products and processes from: hiring skilled employees from other organisations; reverse engineering; and in-house R&D. It is quite possible that an organisation which does everything in-house may rate very poorly on *AbsorptiveCapacity* but very highly on *InternalCapacity*.

Determinants. Section 4 identifies six main determinants of absorptive capacity: the stock of knowledge assets and five augmenting factors. These determinants of absorptive capacity are measured in the following manner (we unfortunately have no measure on the extent to which the organisation engages in collaborative activities):

1. The stock of knowledge assets, denoted *Stock*, is the mean of two survey questions on the importance of staff with especially valuable product, process or organisational knowledge

⁹ This intuition might not always hold. For instance, one could argue that absorptive capacity is particularly important for new-to-the-world innovations that are cumulative and have a short life-cycle (such as telecommunication technologies). In that case, fast absorption of competitors' innovations is critical to bring new products to the market. Our data does not allow us to dig deeper into these dynamics.

skills. We can also differentiate in our measure between managerial, professional and 'other employees' with these skills.

2. The amount of in-house R&D activity, which we denote as R&D exp, is measured as the response to one question on the extent to which the organisation has devoted resources to R&D expenditure (noting that this is not the same as the extent to which the organisation has learnt from in-house R&D).
3. Production experience, which we denote as Retain, which is the mean of two questions on the extent to which the organisation uses different measures to retain its valuable employees. These measures comprise: ensuring they have interesting work; and ensuring they develop their skills and knowledge on the job.
4. Formal staff training and staff attendance at conferences, seminars and networking occasions were measured as two variables: *Train* which is the mean of three questions on the extent to which the organisation: provides formal training programs to teach new employees the specific skills needed to perform their jobs; provides training (either inside or outside the organisation) to help keep employees' skills up to date; and has people regularly working at multiple jobs or receiving cross-training to increase the number of skills they possess. The second variable *Conference* is the mean of two questions on the extent to which the organisation provides secondments for professional development, and sends employees to conferences and professional programs.
5. Knowledge management, which we denote as KM, is the mean of 12 questions on the extent to which the organisation: rewards employees based on how well they perform the job; rewards employees based on how well their work group or team performs; rewards employees based on how well the organisation performs; has a performance appraisal system that helps to ensure that its reward-based pay plan is effective; has a clear strategic mission that is well communicated and understood throughout the organisation; uses a number of procedures to communicate important information to employees; utilises teams which have responsibility for decisions, assigning work and determining work methods; involves employees in decisions that directly affect their work processes; acts on suggestions and feedback provided by employees; regularly conducts formal appraisals of employees' performance; has a formal grievance procedure or formal complaint resolution system for employees; has transparent systems to address poorly performing employees.

Effects. For the effects of absorptive capacity (realized absorptive capacity), we have two measures of the extent of innovation: $\text{ExtentInnovation}^{\text{NTTW}}$ is the mean of two questions on the extent to which the organisation has, over the past three years, produced many lines of products or services and made major changes in products or service lines, multiplied by a question on the extent to which this is new to the world. $\text{ExtentInnovation}^{\text{NTTF}}$ is defined analogously except that it relates to new-to-the-firm innovations.

A more final measure of the effects of absorptive capacity is how successful the organisation is as an innovator. We measure the success as a new-to-the-world innovator, $\text{SuccessfulInnovation}^{\text{NTTW}}$, as $\text{ExtentInnovation}^{\text{NTTW}}$ multiplied by three questions reporting success: whether it is deemed to have commercial potential; whether it has been commercialised; and whether it has proven to be successful

on the market. The last ‘success’ measure includes all non-missing and non-‘don’t know’ responses from the mean to minimise potential censoring in the data. SuccessfulInnovation^{NTTF} is estimated in an analogous manner for new-to-the-firm innovation.

Table B1 in Appendix B gives the exact survey questions used for each measure.

5.2 Empirical model

We model the relationship between a measure of absorptive capacity and (i) its determinants and (ii) its effects on firm performance in the following manner:

$$\text{AbsorptiveCapacity} = f_1(\text{Stock, R\&D exp, Retain, Train, Conference, KM}) \quad (1)$$

$$\text{InternalCapacity} = f_2(\text{AbsorptiveCapacity, Stock, R\&D exp, Retain, Train, Conference, KM}) \quad (2)$$

$$\text{ExtentInnovation}^{\text{NTTW}} = f_3(\text{AbsorptiveCapacity, InternalCapacity; } Y\gamma) \quad (3)$$

$$\text{ExtentInnovation}^{\text{NTTF}} = f_4(\text{AbsorptiveCapacity, InternalCapacity; } Y\delta) \quad (4)$$

$$\text{SuccessfulInnovation}^{\text{NTTW}} = f_5(\text{AbsorptiveCapacity, InternalCapacity; } Z\theta) \quad (5)$$

$$\text{SuccessfulInnovation}^{\text{NTTF}} = f_6(\text{AbsorptiveCapacity, InternalCapacity; } Z\vartheta) \quad (6)$$

where Y and Z are vectors of covariates; and γ , δ , θ and ϑ are the vectors of parameters. In our model, we include selected variables on entrepreneurial posture, competitive strategy and the commercial environment in the Y and Z vectors. These are included as control variables only.

As foreshadowed, the model is estimated as a system of equations using data from the Melbourne Institute Business survey. Although Likert scale surveys have a number of advantages, they are subject to two forms of potential measurement bias. First, respondents may vary according to how they rate a matter that is ‘important’ or ‘unimportant’. That is, if a matter is considered somewhat important, do they rate this as a ‘5’ or a ‘6’ or even a ‘4’? Second, respondents may be non-objective about questions that may discredit themselves or their organisation. The latter is known in the literature as ‘social desirability bias’ and is especially prevalent among sensitive personal questions.¹⁰

The first type of bias may be dealt with through a number of means: Arundel et al. (1998) suggest using the maximum or minimum of responses to questions overall for each respondent to normalised answers. This means that after normalisation, the distribution of responses for each respondent is similar. In this report, we use another method. As this measurement problem affects all questions answered by a given individual, the seemingly unrelated regression technique — which accommodates correlated errors across the equations for the same respondent — has been used. Accordingly, we use a three-stage-least-squares (3SLS) estimation method which combines the seemingly unrelated regression technique with a system of equations.

The second type of measurement bias can be addressed by using specially inserted questions, such as the Marlowe–Crowne Social Desirability scale, which can then be used to adjust the raw responses

¹⁰ This bias occurs when respondents are motivated to over- or under-report their responses according to how strongly prescribed the value is within their organisational or social system.

(Fisher and Katz 2000). This option is not available for our dataset because these questions are not part of the survey instrument. However, there is no evidence that our data are affected by the desirability bias. Distribution of responses to the constructed variables, shown in Appendix Table B2, indicates that most variables have means and medians within the 3–5 band and similar standard deviations, except for the measures of innovation performance.

5.3 Descriptive analysis

Table 2 presents a comparison of the mean values for the constructed variables used in our regression analysis for both large organisations and SMEs. An SME, in our context, is an organisation with less than 200 employees. We also conducted a statistical test to see whether there is a difference, statistically speaking, between the means for large organisations and SMEs for each constructed variable. This statistical test is called a t-test. Asterisks in the final column indicate that the means are statistically different. The more asterisks, the more confident we are that there is a difference between large organisations and SMEs. Briefly, Table 2 reveals that large organisations are significantly more likely to report a higher level of absorptive capacity and internal capacity for learning about new products and processes. However, both types of organisation reported that they learnt more from external sources than internal sources.

The stock of knowledge assets was also assessed to be greater in large organisations compared with SMEs, and this difference held for all categories of employees (management, professional specialists and other employees). Importantly, in SMEs, management was rated the most important type of employee, although in large organisations, professional specialists were rated the highest. SMEs were least likely to report that professional specialists were an important component of their knowledge assets, probably reflecting a lower employment rate of professional workers among SMEs.

All five forms of absorptive capacity augmenting activities were rated as being more prevalent in large firms than in SMEs. This includes the level of R&D activity; actions taken to retain valuable employees; formal training and conference activities; and the sophistication of knowledge management systems. Within both the SME and large organisation sectors, actions taken to retain valuable employees were rated as the most commonly used mechanism to augment absorptive capacity, but R&D activity was the least used mechanism. The largest differences between both sectors are found for conference activities and the sophistication of knowledge management systems.

Large organisations are also more likely than SMEs to attempt both new-to-the-world and new-to-the-firm innovations. Both sized sectors, though, are considerably more likely to undertake new-to-the-firm innovation than new-to-the-world innovation, as we would expect. The amount of successful innovation reflects this greater willingness to try to innovate. If we consider the success rates (as measured on the Likert scale) we find that large firms rate themselves more successful than SMEs for both new-to-the-world and new-to-the-firm innovations. New-to-the-firm innovations are more likely to be successful than new-to-the-world innovations. This finding is consistent with the fact that new-to-the-world innovations bear a high-level of technological and market risks.

Finally, the control variables are not without their own interest. Respondents from large organisations are more likely to believe that their senior managers adopted a bold and aggressive posture with respect to risk and competitors. Large organisations were also more likely to believe that they adopted a competitive strategy that emphasised increased efficiency, and SMEs were more likely to believe that they were consumer orientated. There was no difference between the two sectors in terms of

how focussed their competitive strategy was on being a product leader or a price cutter. With respect to the commercial environment, SMEs were more likely to agree that the rate of obsolescence in their industry was high and that barriers-to-entry to their market were low. There was no difference in how they assessed the speed of change of their production/service technology.

Table 2 presents the mean levels of absorptive capacity and internal capacity by 1-digit industry (using the ANZSIC 1993 classifications). It reveals that organisations from Education and Communication Services had the highest levels of absorptive capacity followed closely by Electricity, Gas and Water Supply. Accommodation, Cafes and Restaurants had the lowest level. The picture for internal capacity was not wholly different. Education had the highest levels of measured internal capacity, but was closely followed by Communication Services, Property and Business Services, Manufacturing, and Mining. Accommodation, Cafes and Restaurants and Retail Trade had the lowest levels. The F-statistic under an Analysis of Variance for Absorptive Capacity is 3.77, ($p= 0.0000$) and for Internal Capacity is 6.55 ($p= 0.0000$) both which strongly reject the null hypothesis that all industries have the same mean.¹¹

¹¹ A visual inspection of the distribution of each variable (absorptive capacity and internal capacity) indicates that each industry is close to a normal distribution. The standard deviations for each variable and each industry are standard deviations of each group are approximately equal (the ratio of largest to smallest sample standard deviation is less than 2:1).

TABLE 2: DESCRIPTIVE STATISTICS

Measure	Scale anchors	Large	SME	t-test statistic	Level of significance
Mode of knowledge acquisition		Mean	Mean		
Absorptive capacity-absorbing from outside	1=Not at all; 7=a very great extent	3.659	3.064	10.296	***
Internal capacity-generating from inside	1=Not at all; 7=a very great extent	3.509	2.659	12.604	***
Stock (of knowledge assets)					
Staff with valuable skills	1=Not at all; 7=a very great extent	5.503	5.266	3.687	***
% management possessing these skills	1=0; 7=100	5.001	3.955	10.964	***
% professional specialists possessing these skills	1=0; 7=100	5.031	3.115	18.450	***
% other employees possessing these skills	1=0; 7=100	3.979	3.741	2.414	**
Absorptive capacity augmenting factors					
R&D expenditure	1=Not at all; 7=a very great extent	3.417	2.661	6.424	***
Retain	1=Not at all; 7=a very great extent	5.036	4.681	5.789	***
Train	1=Not at all; 7=a very great extent	4.848	4.072	11.448	***
Conferences	1=Not at all; 7=a very great extent	4.212	3.214	11.948	***
Knowledge management	1=Not at all; 7=a very great extent	4.817	3.845	16.379	***
Innovation activity					
Extent of new-to-the-world innovation	1=Not at all; 7=a very great extent	1.482	1.241	2.685	***
Extent of new-to-the-firm innovation	1=Not at all; 7=a very great extent	2.540	2.198	3.231	***
Success of new-to-the-world innovation	1=Not at all; 7=a very great extent	0.783	0.578	2.633	***
Success of new-to-the-firm innovation	1=Not at all; 7=a very great extent	1.396	1.181	2.351	**
Other control variables					
Entrepreneurial posture					
Bold	1=Not at all; 7=a very great extent	3.680	3.523	2.009	**
Aggressive	1=Not at all; 7=a very great extent	4.332	4.037	4.134	***
Competitive strategy					
Increase efficiency	1=Not at all; 7=a very great extent	5.186	4.819	5.828	***

Customer orientated	1=Not at all; 7=a very great extent	5.240	5.741	-7.566	***
Product leader	1=Not at all; 7=a very great extent	4.269	4.268	0.017	
Price cutter	1=Not at all; 7=a very great extent	3.643	3.627	0.209	
Environment					
The rate of obsolescence is very high	1=Not at all; 7=a very great extent	3.283	3.518	-2.345	**
The production/service technology often changes in a major way	1=Not at all; 7=a very great extent	3.929	3.851	0.834	
Entry barriers are very high. It is very difficult for new competitors to enter the market	1=Not at all; 7=a very great extent	4.812	3.776	9.235	***
Maximum sample size		1454	305		

Note: t-test tests that the difference in means between the Large and SME populations are statistically different for *** $p < 0.01$, ** $p < 0.05$ and * $p < 0.1$.

Source: Melbourne Institute Business Surveys 2004–2012.

TABLE 3: CHARACTERISTICS OF SURVEYED ORGANISATIONS, AUSTRALIA, 2004–2012

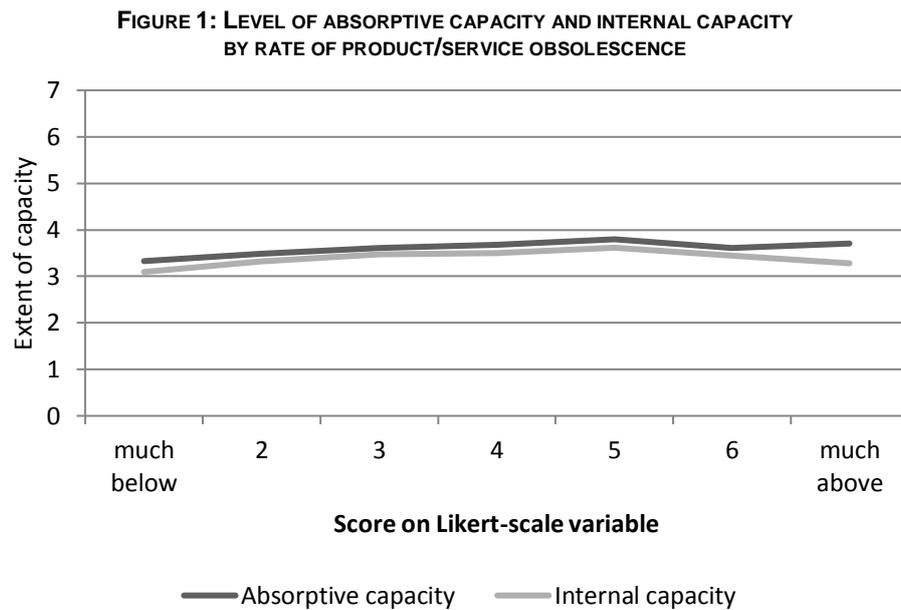
Industry group	Absorptive capacity-absorbing from outside		Internal capacity-generating from inside	
	Mean	Std dev.	Mean	Std dev.
Agriculture, Forestry & Fishing	3.296	0.970	3.359	1.172
Mining	3.702	1.176	3.696	1.149
Manufacturing	3.510	0.903	3.650	1.095
Electricity, Gas & Water Supply	3.849	0.910	3.389	1.032
Construction	3.455	0.852	3.209	1.058
Wholesale Trade	3.423	0.963	3.026	1.255
Retail Trade	3.400	0.996	2.915	1.225
Accommodation, Cafes & Restaurants	2.891	0.963	2.725	1.041
Transport & Storage	3.493	0.871	3.015	0.980
Communication Services	4.066	0.719	3.618	0.884
Finance & Insurance	3.519	0.926	3.398	1.114
Property & Business Services	3.700	1.011	3.639	1.015
Government Administration & Defence	3.656	0.880	3.397	0.924
Education	4.095	0.927	3.772	1.017
Health & Community Services	3.619	1.059	3.225	1.184
Cultural & Recreational Services	3.659	1.074	3.590	1.123
Personal & Other Services	3.703	0.883	3.443	0.969
Total	3.567	0.964	3.384	1.133

Note: Excludes observations with missing industry information. Highest (lowest) values are reported in bold (italic). Both large organisation and SME populations for the survey were coded according to industry classification ANZSIC93 and accordingly we used this version for this table.

Source: Melbourne Institute Business Surveys 2004–2012.

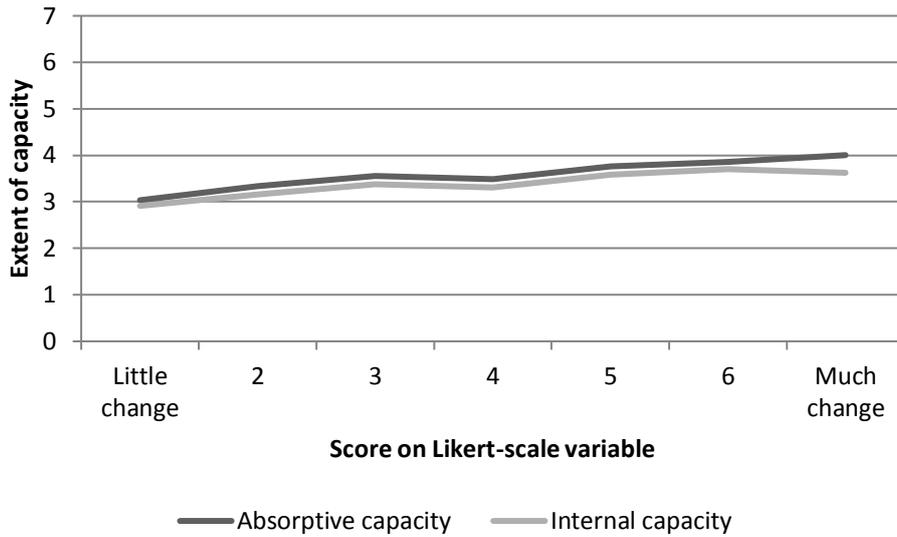
We can also report the mean level of absorptive capacity and internal capacity by a range of market environment variables. We represent these relationships below in Figures 1 to 5. Briefly, they reveal that absorptive capacity (which is highly correlated with internal capacity) is higher (the correlation is statistically significant at the 5 per cent level):

- the higher is the rate of product/service obsolescence;
- the higher is the rate of change in the product/service (but the statistical significant only hold for internal capacity);
- the higher are the barriers to entry to the organisation's market;
- the more concentrated is the industry; and
- the lower is staff turnover (but the statistical significant only hold for absorptive capacity).



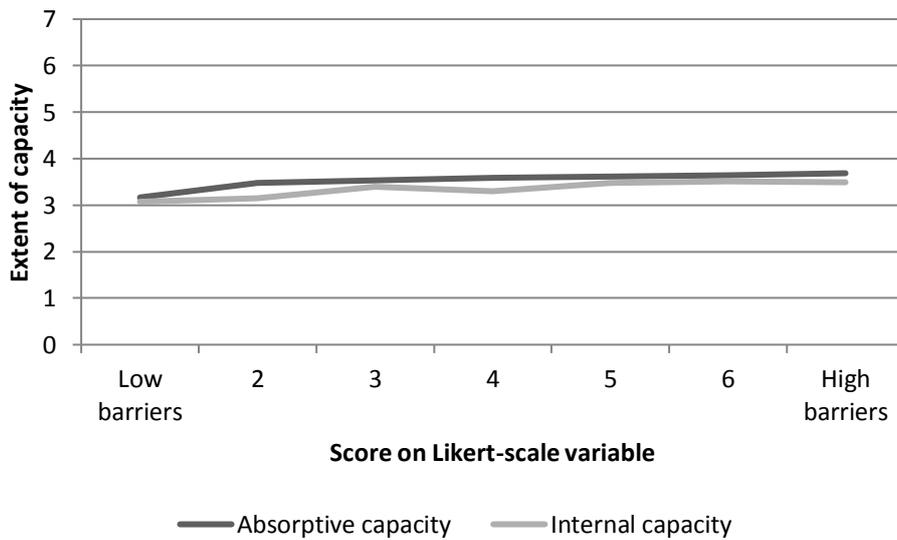
Notes: Regression equation is $y = 0.0573x + 3.3733$ for absorptive capacity ($R^2 = 0.6331$) and $y = 0.0335x + 3.2544$ for internal capacity ($R^2 = 0.1804$).

FIGURE 2: LEVEL OF ABSORPTIVE CAPACITY AND INTERNAL CAPACITY BY CHANGE IN PRODUCT/SERVICE TECHNOLOGY



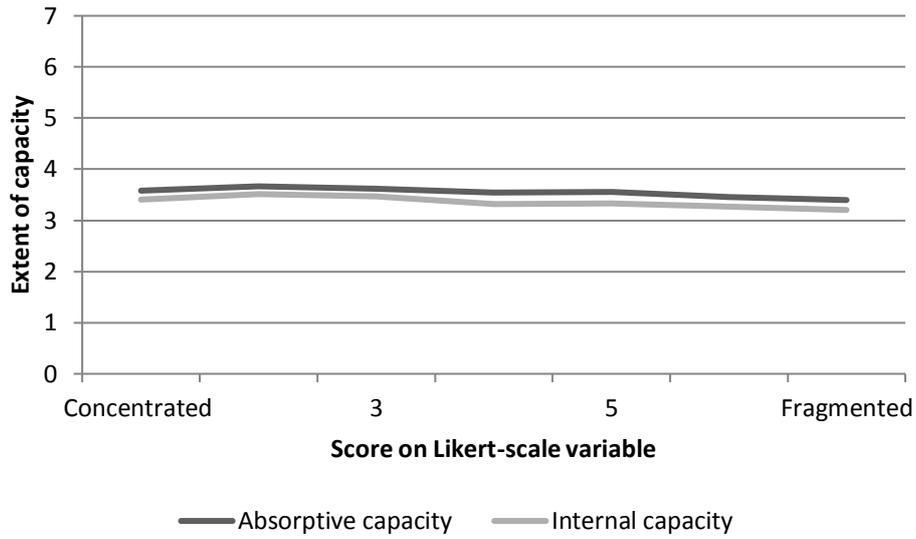
Notes: Regression equation is $y = 0.1482x + 2.9859$ for absorptive capacity ($R^2 = 0.9387$) and $y = 0.1224x + 2.8907$ for internal capacity ($R^2 = 0.8784$).

FIGURE 3: LEVEL OF ABSORPTIVE CAPACITY AND INTERNAL CAPACITY BY BARRIERS TO MARKET ENTRY TECHNOLOGY



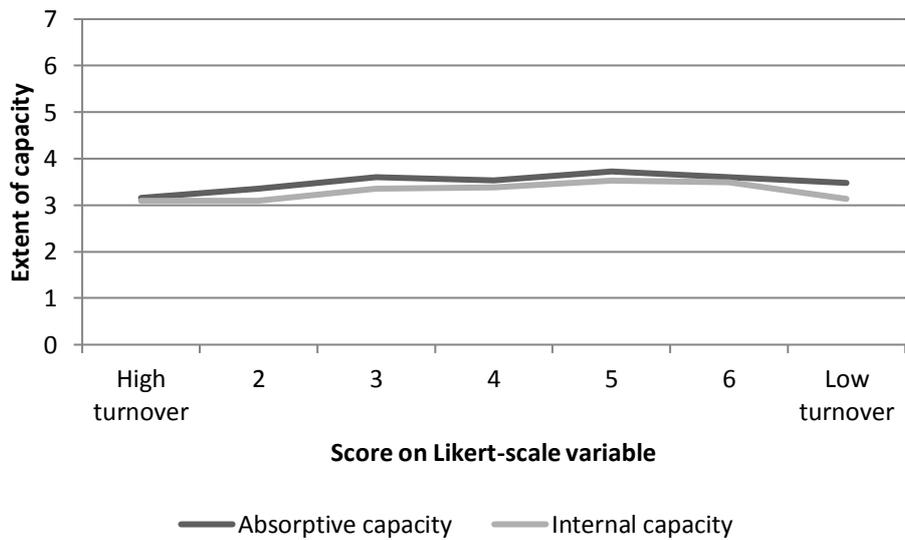
Notes: Regression equation is $y = 0.0708x + 3.2482$ for absorptive capacity ($R^2 = 0.7632$) and $y = 0.0733x + 3.0492$ for internal capacity ($R^2 = 0.8278$).

FIGURE 4: LEVEL OF ABSORPTIVE CAPACITY AND INTERNAL CAPACITY BY INDUSTRY CONCENTRATION



Notes: Regression equation is $y = -0.037x + 3.6932$ for absorptive capacity ($R^2 = 0.7358$) and $y = -0.043x + 3.5296$ for internal capacity ($R^2 = 0.7329$)

FIGURE 5: LEVEL OF ABSORPTIVE CAPACITY AND INTERNAL CAPACITY BY STAFF TURNOVER



Notes: Regression equation is $y = 0.0567x + 3.2671$ for absorptive capacity ($R^2 = 0.4199$) and $y = 0.0397x + 3.1394$ for internal capacity ($R^2 = 0.2127$)

5.4 Econometric results

In Table 3, we exclude variables that were not statistically significant unless we particularly want to highlight their lack of effect.¹² We begin with the twin equations to estimate the determinants of the mode of knowledge acquisitions — via absorbing external information or creating from within their own resources. With respect to equation (1) on the determinants of absorptive capacity, we note that the stock of knowledge assets has a significant effect on the magnitude of the organisation's measured absorptive capacity. In particular, this was related to the percentage of professional specialists and other employees with these skills. It was not related to the percentage of managers with these valuable skills. Of those factors highlighted in the literature as augmenting factors, R&D expenditure, conference and knowledge management systems did appear to affect the magnitude of absorptive capacity. Measures to retain valuable staff and the emphasis given to formal training did not appear to have any impact (and recall we have no measure for the extent of inter-organisation collaboration). We included a dummy variable for SME status to test for the effects of SME status per se, but it was not statistically significant. This leads us to conclude that differences in the explanatory variables account for the difference between large and SME levels of absorptive capacity.

The explanation for the magnitude of the organisation's capacity for generating ideas internally is in many respects similar. For equation (2), we included the magnitude of absorptive capacity as an explanatory variable on the basis that openness to new ideas may affect how well ideas are also generated internally. We find that the size of absorptive capacity has a large and (near) equal determining effect on internal capacity as R&D expenditure. Smaller effects arose from the frequency of staff training, conferences and the sophistication of the organisation's knowledge management system. However, there appears to be a discount for SMEs compared with large organisations: for given levels of the explanatory variables, the level of internal capacity generated is lower for SMEs. This SME effect could reflect the need for a critical mass of employees in order to reach the full learning potential.

Equations (3) and (4) estimate the determinants of the extent to which organisations attempt new-to-the-world and new-to-the-firm innovations. In these equations, we include as explanatory variables the magnitudes of absorptive capacity and internal capacity as well as the series of control variables relating to the entrepreneurial posture, competitive strategy and environment. We find that whereas internal capacity is a statistically significant and large driver of the extent of both types of innovation, absorptive capacity appears to have no direct impact on new-to-the-world innovation and only a small effect on new-to-the-firm innovation. This implies that the way in which absorptive capacity affects innovation appears to be mainly via its effect on internal capacity: absorptive capacity improves firms' internal learning capacity which, in turns, increases innovativeness. The fact that absorptive capacity has no direct effect on new-to-the-world innovations but well on new-to-the-firm innovations is consistent with the fact that new-to-the-firm innovation activities involves copying, inventing around and adapting competitors' products.

A similar result is found for the success of new-to-the-world and new-to-the-firm innovation: in the estimations for equations (5) and (6), internal capacity was a significant and large determinant of

¹² As mentioned, we chose to estimate equations (1) to (6) as a seemingly unrelated regression (SUR). Although the equations could be estimated separately from each other, the fact that each set of equations has a common respondent can be used to increase the efficiency of the estimates. SUR equations consider that the error terms are correlated within respondents, improving the efficiency of the estimates.

success and the effect of absorptive capacity appeared to be only via its impact on internal capacity. Appendix D presents details of the extent of R&D expenditure by firm size. It shows that 38.9 per cent and 19.8 per cent of SMEs and large organisations respectively have not conducted R&D over the last three years.

The control variables are worth looking at and in Table 3 we present only those that are significant. Briefly, attempting new-to-the-world innovation was associated with (i) a more aggressive (and risk taking) entrepreneurial posture; (ii) a product leader who is not especially consumer orientated; and (iii) operating in industries with high technological obsolescence. Attempting new-to-the-firm innovation was associated with (i) an aggressive entrepreneurial posture and (ii) a high rate of technological obsolescence, but was not associated with a particular competitive strategy. Both successful new-to-the-world and new-to-the-firm innovators were associated with (i) a more aggressive entrepreneurial posture; (ii) being a product leader; and (iii) operating in an industry with a high rate of technological obsolescence. Interestingly, a higher level of absorptive capacity was associated with a lower success rate for new-to-the-world innovation, although the size of the coefficient was small and only significant at the 10 per cent level.

**TABLE 3: DETERMINANTS AND EFFECTS OF ABSORPTIVE CAPACITY:
SYSTEM OF EQUATIONS (SEEMINGLY UNRELATED REGRESSION EQUATIONS)**

Independent variables	Dependent variables					
	Absorptive capacity-absorbing from outside	Internal capacity-generating from inside	Extent of new-to-the-world innovation	Extent of new-to-the-firm innovation	Success of new-to-the-world innovation	Success of new-to-the-firm innovation
Mode of knowledge acquisition						
Absorptive capacity-absorbing from outside		0.282*** (0.0263)	0.00532 (0.0398)	0.107** (0.0488)	-0.0633* (0.0373)	-0.0692 (0.0443)
Internal capacity-generating from inside			0.430*** (0.0349)	0.559*** (0.0428)	0.338*** (0.0328)	0.455*** (0.0388)
Stock of knowledge assets						
Staff with valuable skills	0.0513** (0.0208)	0.0229 (0.0204)				
% professional specialists possessing these skills	0.0349** (0.0147)	0.0354** (0.0145)				
% other employees possessing these skills	0.0481*** (0.0157)	-0.00283 (0.0154)				
Absorptive capacity augmenting factors						
R&D expenditure	0.124*** (0.0112)	0.304*** (0.0115)				
Retain	0.00308 (0.0269)	-0.0292 (0.0264)				
Train	-0.00368 (0.0218)	0.0453** (0.0213)				
Conferences	0.159*** (0.0182)	0.0332* (0.0183)				
Knowledge management	0.138*** (0.0279)	0.0774*** (0.0276)				
Other control variables						
Entrepreneurial posture						
Aggressive			0.164*** (0.0312)	0.153*** (0.0383)	0.124*** (0.0293)	0.160*** (0.0347)
Competitive strategy						
Customer orientated			-0.0609*** (0.0140)	-0.0189 (0.0248)		
Product leader			0.259*** (0.0313)	0.198*** (0.0394)	0.207*** (0.0287)	0.184*** (0.0341)
Environment						
The rate of obsolescence is very high			0.129*** (0.0186)	0.0933*** (0.0229)	0.0941*** (0.0175)	0.0548*** (0.0207)
Entry barriers are very high, difficult to enter the market					-0.00118 (0.00659)	-0.0353*** (0.0112)
SME	0.0505 (0.0646)	-0.167*** (0.0636)	0.00297 (0.0901)	0.0568 (0.110)	-0.0520 (0.0845)	-0.0194 (0.100)
Observations	1,399	1,399	1,399	1,399	1,399	1,399
R-squared	0.322	0.552	0.330	0.288	0.251	0.229

Notes: Standard errors are in parentheses. *** p<0.01, ** p<0.05 and * p<0.1.

6. Conclusions and policy implications

Our investigation uses a large firm-level dataset to analyse the level, determinants and effects of absorptive capacity.

Level. We use revealed preference theory to devise a measure of the level of absorptive capacity. Specifically, we use survey questions on how successful the firm has been in acquiring its new ideas and technologies from external sources to reveal how much capacity it has to absorb these ideas. To complement this measure, we also devise an analogous measure of how much capacity the firm has to generate new ideas and technologies from within itself.

Determinants. Following the literature, we test the hypothesis that the degree of absorptive capacity held by each firm is a function of the its stock of knowledge assets; current levels of R&D activity; its retention of valued staff; investments into staff training and its exposure to conferences and networking occasions; and the sophistication of its knowledge management systems. Ideally, we would include a measure of collaboration, however our survey does not have this indicator.

Effects. Finally, we test the hypothesis that absorptive capacity affects both the extent and success of innovation. We specifically distinguish between new-to-the-world and new-to-the-firm innovations. We expect the relationship between absorptive capacity and new-to-the-firm innovation to be more pronounced than the relationship between absorptive capacity and new-to-the-world innovation because new-to-the-firm innovations depend heavily on external knowledge.

Our analysis shows that absorptive capacity is one of the major determinants of innovation (both the extent to which firms attempt to innovate and the extent to which they are successful in innovating). However, its effect is indirect. Absorptive capacity mainly operates via enhancing the organisations internal capacity for generating new ideas. The distinction between externally and internally acquired knowledge has not been well addressed in the literature and we are not aware of any other studies that have tried to estimate the separate effect. We also we found that:

- Large organisations had significantly higher levels of both absorptive capacity and internal capacity than SMEs.
- Organisations from both Education and Communication Services had the highest levels of absorptive capacity followed closely by Electricity, Gas and Water Supply. Education had the highest levels of measured internal capacity, but was closely followed by Communication Services, Property and Business Services, Manufacturing, and Mining. These high levels of absorptive capacity and internal capacity may well be driven by the large size of organisations in these industries.
- Accommodation, Cafes and Restaurants had the lowest level of both absorptive capacity and internal capacity. Retail Trade also had a low mean level of internal capacity.
- Market environment factors were shown to be associated with the level of absorptive capacity (and internal capacity). We can observe from our data that absorptive capacity is higher: the higher is the rate of product/service obsolescence; the higher is the rate of change in the product/service; the higher are the barriers to entry to the organisation's market; the more concentrated is the industry; and the lower is staff turnover.

- To the extent our associations reveal determinants, the main determinants of absorptive capacity were (in rank order): the extent to which employees are encouraged to attend conferences and undertake secondments; the sophistication of the firm's knowledge management system; R&D expenditure; and the stock of knowledge assets derived from professional and other non-managerial employees. The two most important determinants of absorptive capacity, conference attendance and sophistication of the knowledge management system, are also those on which SMEs score lowest relative to large firms. Measures to retain valuable staff – that is, ensure they have interesting work and ensure they develop their skills and knowledge on the job- and the emphasis given to formal training do not appear to be correlated with absorptive capacity. However, other organisational behaviours such as developing workers skills via conferences and secondments and knowledge management techniques (as described above) are significant. We cannot be completely sure about the direction of causation however.
- Absorptive capacity was highly correlated at the organisational level with the ability of the organisation to generate ideas internally. Similarly to absorptive capacity, internal capacity was related to: the stock of knowledge assets derived from professional specialist employees; R&D expenditure; the extent to which employees are encouraged to attend conferences and undertake secondments; and the sophistication of the organisation's knowledge management system. Unlike absorptive capacity, internal capacity was associated with the extent to which the organisation provides formal training for employees.
- The extent of innovation performed and its success in the market place was heavily influenced by the level of internal capacity. Except for the extent of new-to-the-firm innovation, the level of absorptive capacity did not have a direct effect.
- Being an SME did not appear to confer any special advantage or disadvantage in either new-to-the-firm or new-to-the-world innovation; or in the levels of innovation undertaken or its success. This statement means once all other given factors are taken into account.

These findings are suggestive and we should not over interpret their significance. They are drawn from a pooled data set and the associations should be more accurately be described as correlations than determinants. We are relying on our a priori theory to convert a statistical correlation into a causal relationship. Leaving this caveat aside, our results have several implications for government intervention in the area of firm performance. Two possible roles exist for government depending on whether we assume that firms are fully efficient or not.

If firms are always fully efficient, meaning they are always on, or close to, the production possibility frontier, then the only clear role for public policy is to increase the rate at which the frontier expands. The position of the frontier is dictated by the most efficient, technologically advanced, firm in the world. If the firm's level of expected quasi-rents from knowledge creation (new-to-the-world innovation) leads to a rate of expansion of the frontier below what is 'optimal' then, there is a case for increasing the firm's share of the total created value. Optimality has a strict meaning in economics. It is the level of activity that maximises the sum of all benefits to all members of society less the sum of all costs imposed on these members. What is optimal in our case, therefore, depends on a full assessment of the social costs and benefits from further knowledge creation activities. We can deduce

however that where the knowledge created by one firm, is learned, copied or captured without payment by another firm,¹³ the economy is *probably* operating below its optimum level of knowledge creation. This is called a market failure. It arises because the incentives to undertake knowledge creation are not aligned with who benefits from such creation – free riding is going on. Where this market failure can be shown to exist, suitable policies include using public monies to create institutions to reduce the costs of R&D; increase the efficiency of trade and specialisation in the market for technology; enhance access to innovation finance; and improve the efficacy of IP. The main issue for policy makers here is to be able to show *empirically* that there are unexploited gains to be had from speeding up or increasing the process of new-to-the-world innovation. This is the classic economics case for knowledge spillovers, market failure and therefore government interventions

Nonetheless, the assumption that all firms are always fully efficient is typically based on *a priori* reasoning and could be said to be an unrealistic assumption on which to base public policy. There is clear and consistent evidence from the empirical literature that there exists a wide dispersion of firm level efficiency for firms in the same industry. Moreover, these efficiency differentials have been shown to be persistent (for Australia evidence see Palangkaraya *et al* 2009). In this case, the persistence of low efficiency (or low productivity) firms occurs because competition is neither as ruthless nor as fast as our *a priori* theories maintain. Inefficient firms fail to challenge efficient firms through offering lower prices or better products with the consequence that efficiency gains are not transmitted quickly to third-parties such as consumers. In this respect markets have failed to deliver: there are spillover benefits from knowledge creation and transmission activities that should be, but are not being, captured by consumers. We may say the inefficient firm is paying the price for its inefficiency in the form of lower profits, but the main effects are being felt by consumers who pay a higher price, for a longer time, for goods and services. How long they pay this price clearly depends on how lethargic the process of competition is. This is the classic management science case for government intervention.

In this respect, society can benefit from intervening in the extent and success of catch-up, or new-to-the-firm, innovation. Our results indicate that the extent of new-to-the-firm innovation is heavily influenced by the level of internal capacity for generating new knowledge and is somewhat influenced by the degree of absorptive capacity. Our survey results show a marked dispersion in the levels of internal capacity and absorptive capacity across firms (although it must be borne in mind that these data are based on subjective survey ratings). Public policy interventions that increase the levels of both absorptive capacity and internal capacity can therefore have significant impacts on societal well-being.

Government might also intervene as employers of organisations, or to facilitate the absorption of publicly funded research and research in national priority areas. An important rationale for government financing of basic research within universities, the CSIRO and other public research organisations (PROs) is to ensure investment in uncertain technologies with a long lead time that would otherwise not be financed. Yet this argument requires that research resulting from public funding will be absorbed by the private sector. As we know from other work, markets for technology are imperfect (Arora and Gambardella 2010; de Rassenfossé *et al.* 2013; Jensen *et al.* 2013), meaning that technologies might not be easily transferred across various actors of the innovation system —

¹³ These are called knowledge spillovers in the literature.

typically from PROs to private firms. In this respect, programmes aimed at facilitating the flow of discoveries from the public sector to the private sector can be funded legitimately by government. Examples of programmes include supporting the temporary exchange of researchers between both sectors, or sponsoring conferences presenting basic research results and other networking events.

Appendix A: Survey process of large organisations and SMEs, 2012

Large organisations

Surveys were sent by an external mailing house to large firms taken from the IBIS World database for each year. The surveys encompassed an invite letter on the survey cover page and a reply-paid envelope was enclosed with the survey. The surveys were personalised and addressed to the firm secretary or similar person/role. The first mail-out to 1767 firms took place on 4 February 2013. A follow-up reminder mail-out to 1563 non-responders took place on 18 March 2013 and included a copy of the survey and a reply-paid envelope. Response details are given in Table A1.

SMEs

The same questionnaire was sent to a stratified sample of randomly selected small and medium-sized enterprises (SMEs) from telephone listings from the year 2010. The sample was stratified by 1-digit industry. The contact details of around 2700 SMEs were searched using the Internet, and where possible they were contacted by telephone in the first instance to request their participation and to verify their contact details. Detailed instructions explaining the purpose of the survey were given by the Melbourne Institute caller. Overall 639 firms agreed to participate and were sent a survey and reply-paid envelope, as well as a \$20 Coles–Myer voucher as an incentive to complete and return the survey (as was discussed in the initial phone call requesting participation). These surveys were mailed in-house in five tranches from 31 January to early April 2013. A follow-up reminder mail-out to 347 non-responders took place on 12 April 2013 and included a survey and reply-paid envelope. Response details are given in Table A1.

Table A2 shows that the industry profile of respondents is quite close to the population profile. For large organisations, there was a slight tendency for large government administration and education industry organisations to respond and a tendency for miners and retail trade firms not to respond. In the SME sector, Manufacturing, Wholesale Trade and Retail Trade were slightly more likely to respond whereas Electricity, Gas and Water Supply, Accommodation, Cafes and Restaurants, Education, Cultural and Recreational Services, and Personal and Other Services were more likely not to respond. However, these under- or over-representations are not large.

TABLE A1: SURVEY RESPONSES FROM 2012 LARGE ORGANISATION AND SME SURVEYS

Survey status	Large	SME
Completed surveys returned	62	315
Return-to-sender	165	22
Don't wish to participate/remove	17	28
Firm no longer exists/merged with another	4	0
Person unknown/deceased/left	57	2
Out of scope (SME)	na	3
TOTAL returns	305	367
Population surveyed	1767	640
No response	1462	273

Note: 'na': not applicable.

TABLE A2: CHARACTERISTICS OF SURVEYED ORGANISATIONS, AUSTRALIA 2001–2012

Industry group	Large organisations		SME (2012)	
	Respondents (%)	Population (%)	Respondents (%)	Population (%)
Agriculture, Forestry & Fishing	1.2	1.3	3.2	2.1
Mining	3.4	8.5	0.5	0.4
Manufacturing	18.6	18.4	32.8	24.0
Electricity, Gas & Water Supply	4.1	2.3	0.0	0.1
Construction	4.9	3.9	4.3	9.4
Wholesale Trade	16.1	14.0	7.0	2.9
Retail Trade	5.4	6.8	16.7	14.4
Accommodation, Cafes & Restaurants	0.8	1.1	5.9	2.3
Transport & Storage	3.8	4.4	3.2	4.4
Communication Services	1.8	1.4	0.0	0.6
Finance & Insurance	10.9	11.5	0.5	2.3
Property & Business Services	11.1	14.2	11.3	16.6
Government Administration & Defence	6.0	3.2	0.0	0.2
Education	3.4	1.6	0.5	2.3
Health & Community Services	3.7	3.8	7.5	7.1
Cultural & Recreational Services	2.9	2.4	2.7	4.7
Personal & Other Services	2.0	1.3	3.8	6.2
Total	100.0	100.0	100.0	100.0

Note: Excludes observations with missing industry information.

Source: Melbourne Institute Business Survey 2001–2012.

Appendix B: Survey variables

TABLE B1: SURVEY QUESTIONS USED TO CONSTRUCT REGRESSION VARIABLES

Variable	Description	Questions/statements	Mean (std dev)	Exact survey item(s)
Mode of knowledge acquisition				
Absorptive capacity- absorbing from outside	A 10-item, 7 point scale measuring the extent to which members of the firm learn about new products and processes	This organisation makes extensive use of learning about new processes and products from: <ul style="list-style-type: none"> - licensing technologies; - patent disclosures; - publications or technical meetings; - informal networks with other organisations; - formal cooperation or networks with other organisations; - lead customers; - suppliers; - consultants. The extent to which our organisation's innovations are: <ul style="list-style-type: none"> - licensed from other businesses; - licensed from universities or research consortia. 	3.583 (0.958)	C2a C2b C2c C2d C2e C2i C2j C2k C4c C4d
Internal capacity- generating from inside	A 5-item, 7 point scale measuring the extent to which members of the firm learn about new products and processes	This organisation makes extensive use of learning about new processes and products from: <ul style="list-style-type: none"> - hiring skilled employees from other organisations; - reverse engineering; - in-house R&D. The extent to which our organisation's innovations are: <ul style="list-style-type: none"> - developed and used in-house; - developed in-house and licensed to others. 	3.401 (1.129)	C2f C2g C2h C4a C4b
Stock of knowledge assets				
Staff with valuable skills	A 2-item, 7 point scale measuring the importance of knowledge workers	Many organisations have staff with especially valuable product, process or organizational knowledge skills: <ul style="list-style-type: none"> - how important are these skills for your competitive standing? - would these staff member be difficult to replace if they left? 	5.470 (1.030)	B2a B2b
% management possessing these skills	Percentage of management with these skills		4.869 (1.487)	If year=2012 B3a B3b B3c If year <2012

% professional specialists possessing these skills	Percentage of professional specialists with these skills		4.802 (1.643)	Management If year=2012 B3e B3f B3g If year<2012 Professional specialists
% other employees possessing these skills	Percentage of other employees with these skills		3.951 (1.387)	B3h
Absorptive capacity augmenting factors				
R&D expenditure	A single item, 7-point scale	During the past 3 years, to what extent has your company devoted resources to R&D expenditure?	3.293 (1.832)	C1f
Retain	A 2-item, 7-point scale measuring the extent of disaggregated decision making within the firm	Measure taken to manage and improve contribution of knowledge workers: - ensure they have interesting work; - ensure they develop their skills and knowledge on the job.	4.986 (0.988)	B4a B4b
Train	A 3-item, 7-point scale measuring the extent of employee involvement in training programs	Our organisation: - provides formal training programs to teach new employees the specific skills needed to perform their jobs; - provides training to help keep employees' skills up to date; - has people regularly work in multiple jobs or receive cross-training to increase the number of skills they possess.	4.750 (1.131)	B1a B1b B1c
Conference	A 5-item, 7-point scale measuring the extent to which the organisation encourages conferences and secondments	Measure taken to manage and improve contribution of knowledge workers: - provide secondments for professional development; - send them to conferences and professional programs.	4.072 (1.375)	B4c B4d
Knowledge management	A 12-item, 7-point scale measuring knowledge management systems	Our organisation: - rewards employees based on how well they perform the job; - rewards employees based on how well their work group or team performs; - rewards employees based on how well the organisation performs; - has a performance appraisal system that helps to ensure that our reward-based pay plan is effective; - has a clear strategic mission that is well communicated and understood throughout the organisation; - uses a number of procedures to communicate important information to employees; - utilises teams which have responsibility for decisions, assigning work and determining work methods; - involves employees in decisions that directly affect their work processes; - acts on suggestions and feedback provided by employees; - regularly conducts formal appraisals of employee performance;	4.694 (1.016)	B1d B1e B1f B1g B1h B1i B1i B1k B1l B1m B1n B1o

		<ul style="list-style-type: none"> - has a formal grievance procedure or formal complaint resolution system for employees; - has transparent systems to address poorly performing employees. 		
Innovation activity				
Extent of innovation ^a	A 2 item, 7-point scale measuring extent of innovative activity in past 3 years	Many new lines of products or services. Major changes in product or service lines.	1.441 (1.351)	C3a C3b
Extent of new-to-the-world innovation	A single item, 7-point scale measuring extent to which these innovations are new-to-the-world × 'Extent of innovation'	Of your organisation's innovations in the last 3 years, what proportion are new-to-the-world × 'Extent of innovation'.	2.483 (1.613)	C3a C3b x C5a
Extent of new-to-the-firm innovation	A single item, 7-point scale measuring extent to which these innovations are new-to-the-firm × 'Extent of innovation'	Of your organisation's innovations in the last 3 years, what proportion are new-to-the-world × 'Extent of innovation'.	0.748 (1.176)	C3a C3b x C5c
Success of new-to-the-world innovation	A 3 item, 7-point scale measuring extent to which new-to-the-world innovations have been commercialised × 'Extent of new-to-the-world innovation'	Of those innovations that are completely new-to-the-world, what proportion: <ul style="list-style-type: none"> - have commercial potential; - have been commercialized; - have proven successful in the market × 'Extent of new-to-the-world innovation'.	1.360 (1.389)	C3a C3b x C5a x C6a C6b C6c
Success of new-to-the-firm innovation	A 3-item, 7-point scale measuring extent to which new-to-the-firm innovations have been commercialised × 'Extent of new-to-the-firm innovation'	Of those innovations that are completely new-to-the-firm, what proportion: <ul style="list-style-type: none"> - have commercial potential; - have been commercialized; - have proven successful in the market × 'Extent of new-to-the-firm innovation'.	1.441 (1.351)	C3a C3b x C5c x C8a C8b C8c
Entrepreneurial posture^d				
Aggressive	A 3-item, 7-point scale measuring the degree to which managers take initiative	My organisation typically initiates actions to which competitors then respond. Is very often the first organisation to introduce new products/services, operating technologies, etc. Typically adopts a very competitive, 'undo- the-competitor' posture.	4.294 (1.159)	D2a D2b D2c
Competitive strategy^c				
Increase efficiency	A 3-item, 7-point scale measuring the organization's competitive strategy	Increases operating efficiencies; Develops new process innovations that reduce costs; Focuses on increasing productivity.	5.139 (1.025)	D5a D5b D5c

Customer orientated	A 3-item, 7-point scale measuring the organization's competitive strategy	Tailors and shapes products/services to fit customers' needs; Develops customer loyalty; Has the flexibility to quickly respond to customer needs.	5.304 (1.085)	D5d D5e D5f
Product leader	A 4-item, 7-point scale measuring the organization's competitive strategy	Produces a continuous stream of state-of-the-art products/services; Is 'first to market' with new products/services; Responds to early market signals concerning areas of opportunity; Develops products/services which are considered the best in the industry.	4.269 (1.247)	D5g D5h D5i D5j
Price cutter	A 3-item, 7-point scale measuring the organization's competitive strategy	Produces products/services at a cost level lower than that of our competitors; Prices below competitors; Produces products/services for lower-priced market segments.	3.641 (1.272)	D5k D5l D5m
Environment^b				
The rate of obsolescence is very high	A single item, 7-point scale	Pair of opposing statements 1='The rate at which products/services are becoming obsolete in the industry is very slow'; 7='The rate of obsolescence is very high (as with some fashion goods)'.	3.313 (1.627)	A2b
Entry barriers are very high, difficult to enter the market	A single item, 7-point scale	Pair of opposing statements 1='Entry barriers to the market are very low. It is quite easy for new competitors to enter the market'; 7='Entry barriers are very high. It is very difficult for new competitors to enter the market'.	3.919 (1.518)	A2f
Change in product/service technology	A single item, 7-point scale	Pair of opposing statements 1='The production/service technology is not subject to much change'; 7='The production/service technology often changes in a major way'.	4.678 (1.855)	A2e
Industry concentration	A single item, 7-point scale	Pair of opposing statements 1='The industry is very concentrated, dominated by firms with large market shares that are able to strongly influence the competitive situation'; 7='The industry is extremely fragmented. No organisation has a significant market share and the power to influence industry events'.	3.919 (1.518)	A2g
Labour turnover	A single item, 7-point scale	Pair of opposing statements 1='We have a high turnover of skilled staff compared with other organisations in this industry'; 7='We have a low skilled staff turnover compared with other organisations in this industry'.	3.347 (1.688)	A2i

Notes: a The *Extent of Innovation* are replicated from Miller and Friesen (1982) and appear to have their origins in Miller's 1976 PhD thesis (Miller and Friesen 1978). These latter two questions have been used in the works of Covin and Slevin (1989), Zahra and Covin (1995), and Koberg et al. (1996) among others.

b The first and third *Environment* questions are replications of that used by Miller and Friesen (1982), but as abovementioned, are likely to be derived from Miller's 1976 PhD thesis.

c The *Competitive Strategy* survey questions are based on Treacy and Wiersema (1995) and Porter (1985). This view is widely supported in a number of studies (e.g. Dess and Davis 1984; Miller 1988), particularly when the firm's competitive strategy aligns with the environment (e.g. Burton et al. 2002; Miller 1988).

d The *Entrepreneurial Posture* questions are exact replications of those used by Covin and Slevin (1989) — some of which are original to themselves and some of which are adaptations from Miller and Friesen (1982) and Khandwalla (1976/77). Since these original studies were published, the questions have been used by Covin (1991), Zahra and Covin (1995), Lumpkin and Dess (1996, 2001), Becherer and Maurer (1997), Sapienza and Grimm (1997), and Barringer and Bluedorn (1999).

Source: Melbourne Institute Business Surveys 2004–2012.

Appendix C: Definitions

Absorptive capacity	A measure of a firm's ability to recognize the value of external information, assimilate it, and apply it to useful (or profitable) ends.
Barriers to entry	Obstacles that make it difficult for challengers to enter a given market. Examples of barriers to entry include, but are not limited to, government regulation, economies of scale, or control of resources.
Econometric analysis	Analysis that relies on statistical methods to study the relations between economic variables.
Industry concentration	Measure that depends on the number of firms and their respective shares of the total production. The lower the number of firms and the higher their respective shares, the higher the industry concentration.
R&D	Research and development.
Revealed preference theory	Economic theory that was formally used by Paul Samuelson in the theory of consumer behaviour. He assumed that the preferences of consumers are revealed (and thereby measured) by their purchasing habits. Measuring preferences by revealed behaviour is more reliable, objective and stable than asking people directly about their preferences.
SME	Small and medium-sized enterprise. An SME, in our context, is a firm with less than 200 employees.

Appendix D: Resources devoted to R&D by firm size

Table D1. Likert scale (1 to 7) responses to the question

'During the past 3 years, to what extent has your company devoted resources to R&D expenditure?'

Resources devoted to R&D over the past 3 years	Large organisations	SME	Total
Not at all =1	19.8	38.9	23.0
2	17.5	15.0	17.1
3	16.1	14.3	15.8
4	14.7	14.3	14.6
5	16.4	9.9	15.3
6	10.8	5.5	9.9
A very great extent =7	4.8	2.1	4.3
Total	100	100	100

Appendix E: Constructing a measure of absorptive capacity from the BLD MURF

We suggest using revealed preference theory to construct a measure of absorptive capacity from existing ABS survey. The BLD MURF has a question:

'Where did this business source ideas and information for the development or introduction of new goods, services, processes or methods.

- Clients, customers or buyers
- Suppliers
- Competitors and other businesses from the same industry
- Consultants
- Websites, journals, research papers, publications
- Professional conferences, seminars, meetings, trade shows
- Industry associations'.

[Not relevant responses omitted]

These questions are only asked on a yes/no basis. They are very close to the questions we have used in this study except for the use of yes/no rather than the Likert scale 1-7 response. We recommend constructing a measure of the level of absorptive capacity in the company as mean of the non-missing responses wherein Yes=1 and No=0. Currently, the ABS has only run this set of questions in 2006-07; 2008-09 and 2010-11.

If the Department was to construct a measure for its own survey purposes it should use the same question as the ABS. This will enable it benchmark its survey results with gold standard survey. Alternatively, the Department could pay to have the ABS extent the survey (and as more questions about learning from within the firm) and undertake the questions annually.

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