Annexure 1: Paper by Professor Stefan Wagner

Comment on Section 4.2 "An estimate of the private value-add of innovation patents" of IP Australia Economic Research Paper 05 "The economic impact of innovation patent"

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23. September 2015

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Context

Section 4.2 "An estimate of the private value-add of innovation patents" of IP Australia Economic Research Paper 05 "The economic impact of innovation patent" provides an estimation of how much private value, in monetary terms, an innovation patent adds to the value of inventions. In line with existing research, it is argued that an invention generates private value for its proprietor independently of patent protection (in the following referred to as the "stand-alone value") and that innovation patents add to the stand-alone value a "patent premium", for example by providing its owner with market power. As detailed in Appendix 4.2 "Estimating the patent premium" of the research paper, the approach chosen by IP Australia relies on information on the value of *individual* inventions for which an innovation patent has been filed (obtained from an inventor survey) and estimates of patent premiums obtained from a scientific publication. The basic idea here is that the value of patented inventions as reported in the survey is the sum of an invention's stand-alone value and the added value obtained from patent protection. In order to estimate monetary value generated of innovation patents, IP Australia applies average industry-level patent premiums derived from US firm-level data as published in Arora, Ceccagnoli and Cohen (2008) to invention-level value information obtained from the survey conducted in 2013.

Arora et al.'s (2008) study is based on the Carnegie Mellon survey (CMS) on industrial R&D conducted in 1994 (see Cohen, Nelson, and Walsh (2000) for more information). This data does not contain invention-level information on an invention's value (stand-alone value) or the premium obtained by protecting it by a patent (patent premium). The CMS survey contains firm-level (more precisely business-unit-level) information related to firms' innovation activities. In order to draw inferences from these observed firm characteristics on economic parameters of interest (most importantly the patent premium), Arora et al. (2008) develop a theoretical model that jointly explains firms' R&D expenditures, R&D productivity (number of inventions produced) and the share of inventions for which patent protection is sought as a function of unknown (to be estimated) economic parameters. In this model, the (unknown) patent premium will affect how much firms will invest in R&D and how many patent applications will be filed (both is observed). Taking their theoretical model (and the underlying assumptions) to the data allows the authors to estimate economic parameters of interest including the patent premium. This approach is called structural modelling (Reiss and Wolak, 2007).

An important aspect of Arora et al.'s (2008) model is that it distinguishes two types of patent premiums: the *expected* and the *conditional* patent premium. The *expected* patent premium is the additional value that a patent application would add to the stand-alone value of *all* inventions made by a firm if a patent would be filed (independent of whether or not a patent actually has been filed). As Arora et al.'s (2008) model assumes that the patent premium is not equal for all innovations of a firm but follows a certain distribution, the expected patent premium might *on average* be negative, but could still be positive for a few inventions for which patent protection is then sought. The average additional value that patent applications add to the subset of inventions for which the patent applications are actually filed is thus positive (it multiplies the stand-alone value by a factor of greater than one, see Figure 2 in Arora et al. (2008)). It is called the conditional patent premium and is conditional on a firm's decision to file a patent application. It is important to note here that it does not consider any further developments during the patent examination process (such as continuations, re-examinations, grant decisions) or developments after a grant decision has been issued (such as payment or non-payment of renewals fees).[1]

As described in Appendix 4.2, IP Australia is choosing a more refined approach than Arora et al. (2008) that does not only focus on the decision to file a patent (application) or not but also considers developments after a patent (application) has been filed. In particular, IP Australia is taking into account choices made by the applicant after the filing, most importantly the decision to certify an innovation patent. Additional assumptions on the relation between these post-filing choices and the patent premium are then introduced to derive the additional value of patent protection: For innovation patents that have been filed but not certified a conditional patent premium of 1 is assumed. This implies that the filing of an innovation patent without subsequent certification does not add to the stand-alone value of an invention but does not reduce it either. On page 80 of IP Australia's report, it is noted that out of the population of 7,331 innovation patents that "remained in force or had expired at full term" only 1,737 (23.7%) have been certified. As a result, for 76.3% of all innovation patents (non-certified) a patent premium of 1 is assumed and for 23.7% of all innovation patents (certified) Arora et al.'s (2008) conditional patent premiums are applied.

Below, I highlight some of the implications of the approach chosen by IP Australia. Please note that my comments do not discuss to what extent the Arora et al. (2008) patent premiums can be transferred to the Australian Innovation Patent system. My comments follow IP Australia's

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[1] Please note that Arora et al. (2008) exploit information on firms' patent applications and not patent grants, see Table 2 of Arora et al. (2008).

assumption that the patent premiums derived from the CMS survey can be transferred over i) time, ii) geographies/markets and iii) type of patents. My comments exclusively focus on the application of the patent premiums in estimating the added value of innovation patents (comment I) and the use of survey data obtained from an inventor survey (comment II).

Comment I: Patent premium

In the application of Arora et al.'s (2008) findings, the conditional patent premium should have been assigned to all filed innovation patents as their original model is driven by an inventor's choice to file a patent application (or not) but does not consider any subsequent choices after the application has been filed. IP Australia's approach awards the conditional patent premium from Arora et al. (2008) only to certified innovation patents while uncertified innovation patents are awarded a premium of only one.

To highlight the effect of this choice, I use the formula for the value-add of innovation patents as point of departure. Following IP Australia's notation on page 80 of the Appendix to IP Australia's report, the added value of innovation patents can be derived from the following equation

$$(1)\quad v^v - v^i = v^v \frac{\sigma\mu_c + (1-\sigma)\mu_f - 1}{\sigma\mu_c + (1-\sigma)\mu_f}.$$

In (1), v^v is the value of a patented invention as reported in the Verve Economics survey (i.e., the sum of an invention's stand-alone value plus the added value from patent protection), v^i is the unobserved invention's stand-alone value, σ is the share of certified innovation patents, μ_c is the conditional patent premium from Arora et al. (2008) and μ_f is set equal to one by IP Australia.

Applying the 23.7% certified vs. 76.3% non-certified share of innovation patents (p. 80 of IP Australia report) and the lowest patent-premium reported in Arora et al. (2008, Table 7) – 1.38 – in order to derive a lower bound for the patent premium yields

$$(2)\quad v^v - v^i = v^v \frac{0.237*1.38+0.763*1-1}{0.237*1.38+0.763*1} = v^v * \frac{0.09006}{1.09006} = v^v * 0.08262.$$

In order to derive an upper bound of the patent premium IP Australia uses the highest premium reported in Arora et al. (2008, Table 7) – 1.62 – which amounts to

$$(3)\quad v^v - v^i = v^v \frac{0.237*1.62+0.763*1-1}{0.237*1.62+0.763*1} = v^v * \frac{0.14694}{1.14694} = v^v * 0.12811.$$

This implies that the approach chosen by IP Australia yields an added-value of innovation patents amounting to 8.3% to 12.8% of an invention's stand-alone value.

On the other hand, if one follows the original model provided by Arora et al. (2008) and does not apply different premiums to non-certified patents and certified patents but focuses solely on an inventor's decision to file a patent the calculations simplify to

$$(4)\quad v^v - v^i = v^v \frac{0.237*1.38+0.763*1.38-1}{0.237*1.38+0.763*1.38} = v^v * \frac{0.38}{1.38} = v^v * 0.2754$$

and

$$(5)\quad v^v - v^i = v^v \frac{0.237*1.62+0.763*1.62-1}{0.237*1.62+0.763*1.62} = v^v * \frac{0.62}{1.62} = v^v * 0.3827.$$

Hence, these calculations yield an added-value of innovation patents amounting to 27.5% to 38.3% of an invention's stand-alone value. This is considerably higher (by a factor of more than 3) than what has been derived by IP Australia. Given that IP Australia found a range of the aggregate value-add created by innovation patents in Australia between 10 million and 40 million AUD, the application of a factor of 3 for both the lower and upper bound of the aggregated value created by innovation patents would yield a range of 30 million to 120 million AUSD. Note however, that these estimations assume that Arora et al.'s (2008) premiums can be applied to Australian innovation patents.

In defence of IP Australia's modelling approach, it needs to be noted that Arora et al. (2008) do assume that patent premiums vary over different inventions of a firm (see Figure 2, Arora et al. (2008)). This fact could be used as justification for a distinction between non-certified and certified innovation patents. Nevertheless, such a distinction makes the application of the patent premiums reported by Arora et al. (2008) challenging for two reasons: First, Arora et al. (2008) report only the mean value of the different patent premiums for inventions. They do not provide further information what the right premium for different types of innovations should be. Even if different premiums are applied to different inventions (as has been done in the report of IP Australia), their weighted mean should be equal to the conditional patent premiums reported in Arora et al. (2008) in order to reflect their results properly. This, however, is not the case in IP Australia's specification. Here the weighted mean is 1.09 (= 0.237*1.38 + 0.763*1) instead of 1.38 for the lower bound and 1.15 instead of 1.62 for the upper bound.

Second, the distinction between non-certified and certified innovation patents might not properly reflect the fact, that some innovation patents do not get certified while being of equal (high) value than certified innovation patents. It is possible that the mere existence of a non-certified innovation patent deters competitors from imitation even without certification if competitors anticipate that a certification would provide the patent holder with a strong and enforceable patent. Based on this anticipation they would not imitate the protected invention. This, in turn, renders certification and enforcement unnecessary for the inventor. In such situations, the patent holder would get the full value-add from an innovation patent without certification. In absence of further information what share of non-certified patents actually deters competitors from imitation any distinction between filed vs. filed seems to be speculative.

Comment II: Patent value

In addition to the patent premium, the value of a patent protected invention v^v is the second corner-stone in deriving the added value of patents. The value of patent protected inventions v^v has been obtained from a survey of inventors which was conducted by Verve Economics. In total, 487 individual responses have been collected and yield a distribution of values across the value categories 0 – 999 AUD, 1,000 – 10,000 AUD, 10,001 – 100,000 AUD, 100,001 – 1,000,000 AUD and more than 1,000,000 AUSD. The distribution is reported in Figure 11 of IP Australia's report (page 77).

In the estimation of the **upper bound** of the value created by innovation patents, the values obtained from the inventor survey v^v have been applied in the estimation mostly "as is" and have been multiplied by the highest patent premium that was derived as described above (see my equation (3)). The only adjustment that has been made is that all patented inventions for which the inventor reported a value of more than 1,000,000 AUD have been treated as having a value of exactly 1,000,000 AUD. Verve Economics, however, reports values of up to 10,000,000 AUD for this category. Given that more than 25% of all respondents reported a value of more than 1,000,000 AUD, this adjustment might underestimate the upper bound of the value generated by innovations patents. Additionally, it should be noted that comparable surveys of patent value show a pronounced right tail of the value distribution, which is also depicted in Figure 11 of the Appendix to IP Australia's report. This right tail of high values is not accounted for in the approach chosen by IP Australia which truncates the distribution at 1,000,000 AUD. In the absence of a scale that contains a more refined measurement of high-value patented inventions (compared to "1,000,000 AUD or higher"), however, it is hard to quantify the exact impact of this adjustment.

Table 1 below demonstrates the sensitivity of the results to the treatment of the highest value category. If it had been assumed that the high-value patents have an average value of 1,500,000 AUD (instead of 1,000,000 AUD) the upper bound estimate would have been 27% higher, with 2,000,000 AUD average value for the highest category 54% higher.

Table 1: Sensitivity analysis of different valuations of the highest value category.

Notes: The reported change is the percentage change relative to the aggregate value where the highest category is valued at 1,000,000 as done in the IP Australia report.

The table is based on the value distribution reported by Verve Economics and reports the aggregated value over the lifetime of the patent protecting an invention. In order to obtain annual figures IP Australia divided these values by 11.17 (years) which is taken as the average lifetime of a patent. Moreover, the aggregate value has been scaled up by IP Australia to reflect the population rather than the Verve sample. The relative changes implied by different treatments of the highest value category, however, still apply.

Response Category	Midpoint value	Observa-tions	Aggregate Value for different treatments of highest category		
			1,000,000	1,500,000	2,000,000
0-999	499.5	14	6,993	6,993	6,993
1,000 - 10,000	5500.5	37	203,519	203,519	203,519
10,001 - 100,000	55000.5	143	7,865,072	7,865,072	7,865,072
100,001 - 1,000,000	550000.5	171	94,050,086	9,405,0086	94,050,086
1,000,0001 or bigger	see column headings	122	122,000,000	183,000,000	244,000,000
Total		**487**	**224,125,669**	**285,125,669**	**346,125,669**
Change				**+27.22%**	**+54.43%**

In order to derive the **lower bound** of the value generated by innovation patents, IP Australia assumes that the Verve Economics survey is not representative and yields a biased picture of the value of patent protected inventions v^v for two potential reasons: First, inventors with high value inventions might be more likely to respond. Second, inventors might simply overestimate the value of their inventions. Both would lead to an upwardly biased picture of actual patent values. In order to correct for this bias the value distribution obtained from the inventor survey has been scaled down as described in Appendix 4.2, page 78.

Since the wording used in the report is ambiguous, I try to replicate the adjustments made by IP Australia in two ways (see Table 2 below): First, I shift 20% of the observations from all categories (except the lowest category) to the next lower one.[2] Second, I shift 20% of the observations of all categories (except the lowest category) directly to the lowest category.[3] In order to quantify the impact of these adjustments, I multiplied the number of (un)adjusted observations by the midpoint of each category. As Table 2 demonstrates, the effect of the adjustments on the value v^v used to compute the added value of innovation patents is between -13% and -20% relative to the value

[2] For instance, 20% of all 122 observations in the highest category (i.e., 0.2*122 = 24.4) are shifted to the second highest category. For the second highest category, 0.2*171 = 34.2 observations are shifted to the third category. The adjusted numbers for the second category are now 171+24.4-34.2 = 161.2.

[3] For instance, 20% of all 122 observations of the highest category (i.e., 0.2*122 = 24.4) are shifted to the lowest category. Equally, for the second highest category, 0.2*171 = 34.2 observations are shifted to the lowest category. The adjusted numbers for the second category are now 171-34.2 = 136.8.

obtained from the original distribution. (Please note, that both approaches do not replicate the reported 38% increase in the number of observations in the lowest category that has been reported by IP Australia. The available information does not explain the different results from my adjustments relative to the adjustment by IP Australia.) This reduction in the aggregate value is in addition to assigning a value of exactly 1,000,000 AUD to the observations in the highest category (see above). Effectively, in the calculation of the lower bound of the value generated by innovation patents the value distribution has been scaled down more than the -13% to -20% reported in Table 2.

Table 2: Adjustments to value distribution.

Notes: Adjustment (1) shifts 20% of the observations of all categories except the lowest category to the next lower category. Adjustment (2) shifts 20% of the observations of all categories except the lowest category to the lowest category. The reported change is the percentage change relative to the aggregate value where the highest category is valued at 1,000,000 as done in the IP Australia report.

The table is based on the value distribution reported by Verve Economics and reports the aggregated value over the lifetime of the patent protecting an invention. In order to obtain annual figures IP Australia divided these values by 11.17 (years) which is taken as the average lifetime of a patent. Moreover, the aggregate value has been scaled up by IP Australia to reflect the population rather than the Verve sample. The relative changes implied by different adjustments of the value distribution, however, still apply.

Response Category	Midpoint value	Observations			Aggregate Value		
		Unadjusted	adjusted (1)	adjusted (2)	unadjusted	adjusted (1)	adjusted (2)
0-999	499.5	14	21.4	108.6	6,993	10,689	54,246
1,000 - 10,000	5,500.5	37	58.2	29.6	203,519	320,129	162,815
10,001 - 100,000	55,000.5	143	148.6	114.4	7,865,072	8,173,074	6,292,057
100,001 - 1,000,000	550,000.5	171	161.2	136.8	94,050,086	88,660,081	75,240,068
1,000,0001 or bigger	1,000,000	122	97.6	97.6	122,000,000	97,600,000	97,600,000
Total		**487**	**487**	**487**	**224,125,669**	**194,763,973**	**179,349,186**
Change						**-13.10%**	**-19.98%**

Without further research, it is hard to verify the existence and to quantify the magnitude of an upward bias in the patent values obtained from the Verve Economics survey. Adjustments are warranted only if a bias exists. Whether adjustments in the range of (more than) -13% to -20% are appropriate to correct for a potential bias remains unclear.

References

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