

## Technical Standards and Trade: A Greater Role for the SDO

G.M.P. (Peter) Swann<sup>1</sup>  
Nottingham University Business School, UK

December 12, 2015

### INTRODUCTION

In 2000, I was asked to prepare a report on *The Economics of Standardization* for the British government, summarising what was known about the field at that time (Swann, 2000). Ten years later, I was asked to update this (Swann, 2010). This short think piece follows on from those earlier reports. It considers this, *purely hypothetical* question: if I were to produce another update, what new topics might it cover? A full update would need to consider a long list, but here I focus on just four issues.<sup>2</sup>

1) You cannot understand all aspects of the economics of standards if you are too specialised in a limited area of economics. For those working on the economics of innovation, which is my field, standards mostly appear to encourage trade. But for those working on the economics of agriculture or the economics of development, the picture is rather different. We examine two contrasting examples which illustrate why these differences arise.

2) Many empirical studies of the effects of standards on trade treat the relationship as something of a black box, and to understand what is going on, we need to open up that box. We give a brief summary of some of the connections to be found in the box. It appears that the number and complexity of linkages has evolved over time, and will probably continue to evolve in future.

3) If the *standards development organisation* (hereafter, SDO) is to develop a full understanding of the economics of standardization, and all the ways in which standards can enhance economic performance, it must involve a wide variety of players. These should include representatives from some the developing countries who can be losers from the process of standardization, and also representatives from various sectors of the economy that have, to date, been absent from the standards table. There is, of course, a substantial gap between the capabilities of some of these new players and the established players in the standards community. Nevertheless, we shall argue that involvement of these new players is good for the standards community as a whole.

4) As the variety of players increases, however, the SDO will have to face a problem that is perhaps, at present, just below the surface. Some of the challenges facing the SDOs can be seen as questions of social choice. Given the different preferences of different participants, how can the SDO reach a

---

1 I am not able to attend the conference, *Mega-Regionalism - New Challenges for Trade and Innovation* (January 20-21, 2016) but I am grateful to Dieter Ernst and Michael Plummer for inviting me to contribute this short 'think piece', and for helpful comments on earlier drafts. I would also like to thank Richard Hawkins, Ray Lambert and Paul Temple for comments and recollections that have helped me clarify my ideas. None of these are responsible for remaining errors.

2 Two other important issues would be the connections between: (a) standards and innovation; (b) standards and IP. However, I do not discuss these here, as they have been reviewed in Swann and Lambert (2016) and Lambert and Temple (2015), respectively.

compromise that is acceptable to all? Arrow's celebrated *impossibility theorem* tells us that this is not a trivial question. Roughly speaking, the problems of social choice become more significant as the diversity of participant preferences increases.. It seems likely, in particular, that these problems may be more common in the context of mega-regions (TPP and TTIP) and the WTO, than in (say) CEN and CENELEC.

**(1) DIFFERENT PERSPECTIVES**

My core specialism is the economics of innovation and that has been a good starting point from which to explore the economics of standards. But I have also learned that you cannot fully understand the economics of standards if you spend all your time studying innovation. Standards generally, though not invariably, play a pretty benign role in the economics of innovation: they support innovation, promote trade and enhance productivity and growth. On the other hand, economists who study agriculture and development can see a very different face of standards: these can create an intransigent barrier to exports from some of the world's poorest countries. Why are things are so different in these two different branches of economics? I shall try to explain this using two contrasting examples.

It is sometimes said that if you open up a personal computer and look at the origins of the components, you see something akin to the United Nations. That is an exaggeration, of course, but you certainly find components from many countries. I myself did this very exercise in 2003, and this is what I found.

*Origin of components in a family PC system (2003)*

Component	Origin
Brand	USA
Assembly of main box	Ireland
Chips on motherboard	USA, Korea, Taiwan, Philippines
Battery	Philippines
CD-ROM drive	China
CD-R (consumables)	Germany
Hard disk drive	Singapore
3.5" disk drive	Philippines
Modem card	Netherlands
Graphics card	China
Specialist video card	USA
Monitor	UK
Keyboard	Mexico
Mouse	Mexico
Child's mouse	Taiwan
Loudspeakers	Malaysia
Microphone	Mexico
Ink-jet printer	Spain
Laser printer	China
Zip drive	Malaysia
Scanner	Taiwan
Web-cam	China
Power supplies	Taiwan, China, Malaysia, Mexico
Manuals	Scotland, Ireland, Wales, Germany
Network switch	China

What does this tell us? Standards for computer components have enabled an extraordinary global division of labour. The organizing principles for that global division of labour are: (a) technological expertise; (b) labour costs; (c) transport costs. In the above table, we can see a pattern where the technologically complex components are produced in the most technologically advanced countries, while the less complex components are produced in lower wage economies. But despite the technologically demanding nature of many of the standards, there is still some action left for less technologically advanced producers. And that happens because of the role of standards in promoting the division of labour. We find a corollary of the old *Babbage principle* of the division of labour: instead of having to find technological competence and low wages at one site, you can find them at different sites and divide the work accordingly.

Now let us turn to the second example: the ground-nuts produced, especially, in West Africa (e.g. Gambia and Senegal). The nuts are ideally suited to poor soils in poor areas, but, unfortunately, they are also susceptible to a naturally occurring fungus called *aflatoxin*. Diop et al (2005) summarise the problem very concisely:

“African countries are facing difficulties meeting EU standards on aflatoxin and stricter product and quality standards ... Aflatoxin has been shown to contribute to liver disease. While the measure is well intentioned ... it has had a tremendously negative impact on the Gambia, whose chief export is peanuts”

Otsuki et al (2001) described the quantitative effects of these EU standards on African exports of ground-nuts:

“The new EU standard, which would reduce health risk by approximately 1.4 deaths per billion a year, will decrease these African exports by 64% or US\$ 670 million, in contrast to regulation set through an international standard.”

When I first read these articles some ten years ago, I felt rather ashamed. Up to that point, I had been a fairly uncritical enthusiast for standards. But reading this impressed on me the how blinkered our vision can become if we focus exclusively on a small sub-section of our discipline.<sup>3</sup>

What is the essential difference between the benign side of standards that we see in the economics of innovation and the far from benign side we see in agriculture and development? It is *not* that standards are invariably too tough in agriculture and development, but weaker in innovation and industry.

The essential difference arises because in the economics of innovation, standards enable a massive international division of labour and production and extensive intra-industry trade. Producers in countries that cannot meet the highest quality standards can grab a piece of the action by producing those components where the key to competitive advantage is not technological sophistication but low wages. So, if you cannot produce the advanced computer chips, you can produce the low tech components (power supplies, microphones, loudspeakers.) In the groundnut case, by contrast, the production process cannot be sub-divided. Either you can produce ground-nuts to the requisite standard, or you cannot. If you cannot, then the opportunities left in that trade are very much reduced.

---

3 The papers in Henson and Wilson (2005) give a good view of the different effects of standards in different contexts.

If we were to go further, and ask scholars across the many sub-divisions of economics what they thought about standards, I suspect we would get an even wider variety of views. But it is not only academic economics that needs to take account of this variety of perspectives; the SDO must do the same, or else it will spend too much time trying to prove that 'red is blue'.

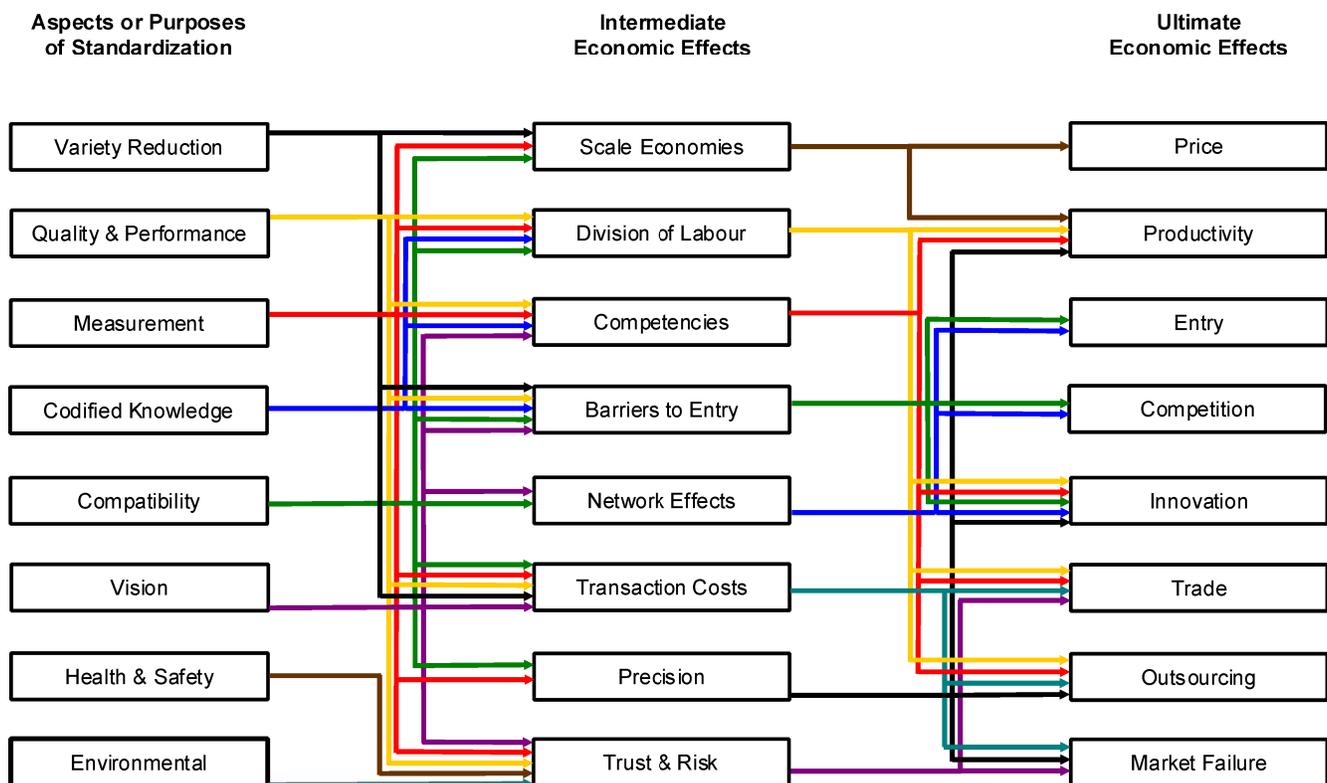
## (2) OPEN UP THE STANDARDS BLACK BOX

In Swann (2010), I noted that many of the recent econometric studies of the macroeconomic effects of standards used a 'black box' approach to modelling, and that it would be helpful to try to open up that black box. In that report, I offered a very preliminary sketch of the linkages which were identified in different parts of the literature. We shall look at this below, but before we do, it is helpful to put this into an historical context.

One of the first surveys of the standards literature (David, 1987) identified three different purposes of the standard. These were:

- compatibility or interoperability
- minimum quality or safety
- variety reduction

David's classification was widely used into the 1990s. But gradually, different authors recognised some additional purposes of standardization. By the time of my 2010 report, that list of three had grown to a list of eight. The colour diagram below shows what I found inside the black box in 2010.



If you have this in full colour, you should be able to follow the various linkages from each purpose of standardization to each intermediate variable and on to each ultimate economic effect. The 2010 report describes what evidence there is for each of the linkages drawn here. How are we to interpret this? Does it simply mean that early scholars did not see all the ways in which standards were being used? Or, was the standard evolving, so that it fulfilled a wider range of economic functions?

I believe that the latter is the correct explanation. Standards were evolving, they were fulfilling new and different purposes, and as a result they were having an impact on a wider range of intermediate and 'headline' economic variables. Moreover, I believe this process of evolution will continue into the future. I conjecture that if we look at all the types and purposes of standards in (say) 2030-35, we would find that the list had grown even further.

In short, if you were to go back to the three purposes identified by David (1987), and delete all the others, the interior of the black box would be much simpler. On the other hand, if you imagine what it might look like in 2030-35, then there would be new categories in each column, more linkages, and the interior of the black box would show a more complex pattern.

### **(3) EVOLUTION OF THE SDO?**

The observations in the last two sections lead on to the proposal in this section. If we are to overcome the sorts of misunderstanding described in section (1), and further to develop the full potential of the standard as described in section (2), then the SDO needs to evolve.

The SDO is an institution that can promote mutual learning amongst a wide range of economic actors, but the extent to which it does that depends on the variety of actors involved in the standardization process. At the time of my 2000 review, a leading view of standardization was that it should be a 'market-led' approach (Daimler Benz, 1998) – in reality, 'market-led' meant, 'business-led'. Over time, however, we have seen a wider range of actors getting involved in standardization.

This is similar to the trend we have seen in innovation. Before the work of von Hippel, innovation was seen primarily as a business process. Then von Hippel (1988) showed how the intelligent user could be an important source of information for the innovator and, in his later work, von Hippel (2005) showed that the user could actually play a role in driving innovation.

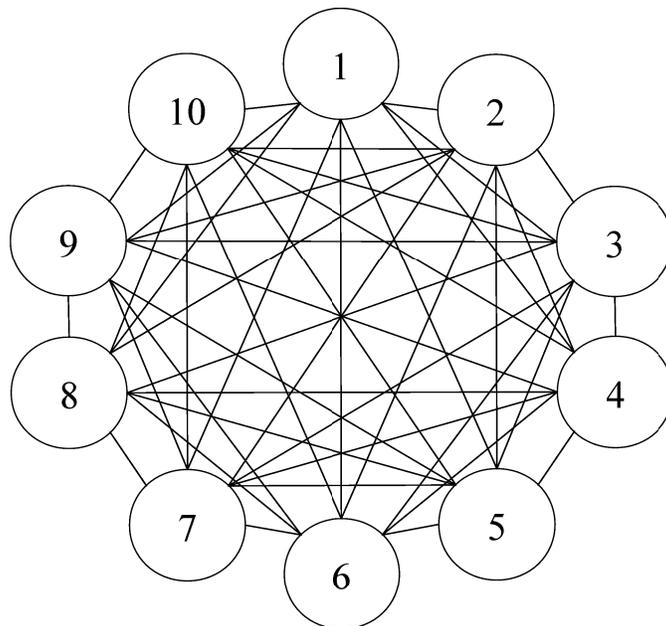
If the SDO is to fulfil its broader potential, it needs to involve a wider group of participants. In the case of section (1), this would involve a wider range of countries, to include some of the present losers from standardization as well as the already-represented winners. In the case of section (2), this would involve a wider range of types of participants – going beyond business, government and science, to include players representing health, the natural environment, the socio-economic environment, consumers, the arts and education.

The analytical framework can be illustrated in a simple diagram (below). This shows (numbered 1-10) the players involved in the SDO, and the web of interactions between these players.<sup>4</sup> Each of these interactions offers an opportunity for one player to learn from another, and by the web of interactions,

---

<sup>4</sup> For those who like metaphor to help them understand an unfamiliar concept, this pattern is like the *tiki-taka* style, made famous in Spanish football (soccer): you may wish to look at this short video of tiki-taka on the training ground: [https://www.youtube.com/watch?v=lxKzwwi\\_aY0](https://www.youtube.com/watch?v=lxKzwwi_aY0)

the knowledge of each participant is shared around the rest.



The Appendix describes a simple *Leontief* model corresponding to this diagram, where members of a network interact and share knowledge to their mutual benefit. It was designed to model innovation in general, and *common innovation* in particular (Swann, 2014), but is applicable to SDOs. If all the interactions are positive definite, then everyone learns from everyone else. But even if some of the interactions are of no economic significance (zero), this mutual learning continues, so long as there are enough positive interactions. A *necessary* condition is that each participant must have an influence on at least one other, and each participant must learn from at least one other.

Since the 2010 DEVCO meeting in Oslo, at least, ISO has sought to increase the involvement of developing countries in SDOs. ISO's goals are set out in its *Action Plan for Developing Countries* (2010). The main emphasis in this document is how developing countries can learn from existing SDO participants, and that is of course very important. But it is also arguable that existing SDO participants can also learn from the involvement of new participants, and that is also very important.<sup>5</sup>

The main difficulty in achieving this ISO goal is that developing countries have very limited capabilities and resources to allow them to participate on the same terms as the existing participants.<sup>6</sup> To take that further may call for some explicit subsidy to developing country participants.<sup>7</sup> If learning is one way only, then such a subsidy simply appears as *largesse* – rather like the principle of *special and differentiated treatment*. But if learning is mutual, then it may be in the interests of existing

---

5 A quick scan of the literature suggests that developed countries can learn from developing countries in many areas, especially the following: health solutions and health services; education systems; micro-finance and micro-credit; growth and equal distribution (e.g. the sharing economy and financial sustainability); innovation in policy making; environmental sustainability. For a full list of references, contact the author.

6 Ernst (2011, 2013) surveys the differences in standardization capabilities and requirements between the US and China.

7 Another approach taken by ISO is *twinning*, where an established member of ISO will undertake to represent the interests of a developing country at ISO meetings (ISO, 2013). While this is a good idea, direct participation by the developing country would be better still.

participants to subsidize the participation of new participants: the appendix explores this possibility.

A similar argument applies in the context of section (2). Indeed, Swann (2000) argued that it could be in the interests of the large players in the SDOs to make a small subsidy to encourage the participation of small players (micro companies and consumer representatives) to attend standards-setting meetings.

#### **(4) STANDARDS DEVELOPMENT AS SOCIAL CHOICE**

While there is a good case for extending participation, we should recognise that this will probably cause a problem to surface in the SDO which is perhaps, at present, just below the surface.

Some of the challenges facing SDOs can be seen as questions of social choice. There are many participants with different preferences towards standardization, and it can be quite a challenge to find a compromise that is acceptable to all.

All graduate students of my generation, certainly, and all of subsequent generations, presumably, were introduced to Arrow's celebrated *impossibility theorem*. Despite this, few of the studies I know that look at choice of standards give much consideration to Arrow's theorem.<sup>8</sup> Perhaps this is because SDOs have, in practice, been able to choose acceptable standards: the problems identified in Arrow's work have not prevented that. My belief, however, is that the theorem may become more relevant as we look at standards-setting in the context of mega-regions (TPP and TTIP) and the WTO.

A brief resumé may be useful. Arrow's *impossibility theorem* refers to the challenge of turning the *individual* preference rankings of a group of voters into a single *social* preference ranking. It states that, there is no voting system that can convert *individual* rankings into a (complete, transitive and deterministic) *social* ranking without violating one or more of these conditions:<sup>9</sup>

- unrestricted domain
- non-dictatorship
- Pareto principle
- independence of irrelevant alternatives (IIA)

These technical terms have the following meanings. The term, *complete*, means that the social ranking puts every option in a rank order: there are no gaps. *Transitive* means that if 'society prefers' A to B, and prefers B to C, then it also prefers A to C. *Deterministic* means that the voting system must produce the same social ranking each time it encounters the same set of individual preferences: there can be no random variations. *Unrestricted Domain* means that the voting system can successfully produce a social ranking for any possible set of individual preferences. *Non-dictatorship* means that the social ranking cannot simply mimic the preferences of a single (dominant) voter. The *Pareto principle* states that if each individual ranks A above B, then the social ranking must also rank A above B. And the *independence of irrelevant alternatives* means that the social preference ranking of A and B

---

8 An exception is the early paper by Demski (1973) on accounting standards. I am grateful to Paul Temple for this reference. Important recent work by Simcoe (2012) and Farrell and Simcoe (2012) is set in the same social choice framework, even if it does not cite Arrow's theorem *per se*. Weiss and Sirbu (1990) provided an important early empirical study of standards choice.

9 I am referring to the later and better-known version of the theorem (Arrow, 1963). To be strictly accurate, I should add that the theorem applies to the case of two or more voters, and three or more distinct alternatives.

must only depend on the individual rankings of A and B.

In short, *something has to give*. It could be one or more of: completeness, transitivity, determinism, unrestricted domain, non-dictatorship, the Pareto principle and IIA.

Some may argue that the Arrow theorem is *too demanding* in the context of the SDO. For example, it could be said that completeness is not necessary. The SDO must find the best standard, but it does not need to provide a complete ranking of all the other possibilities. It could also be said that while the theorem is correct, when viewed over unrestricted domain, SDOs have mostly been lucky enough to work in a more *restricted* domain where the different individual rankings are sufficiently similar that a social ranking can be obtained. Moreover, it has been argued that violation of IIA is not necessarily a serious problem. Nevertheless, violation of non-dictatorship or the Pareto principle seems pretty serious: the first seems deeply undemocratic, while the second seems highly perverse.

On the other hand, it could equally be argued that the Arrow theorem is *not demanding enough*. If we limit our attention to a restricted domain, it may be that a voting system exists which does provide a complete social ranking for the SDO. But that mathematical result does not necessarily imply the system will be politically acceptable to all members of the SDO.<sup>10</sup>

As a practical matter, when impossibility problems most likely to arise? There are two particular cases.

**(a) Cyclicality:** A critical problem is that of *cyclicality*. Indeed, this was known to Condorcet (1785) who identified a voting paradox that arises with cyclical preferences. Consider three voters (1, 2 and 3) and three choices (A, B, C). Suppose that these three voters rank the three choices as follows:

1: ABC (i.e. A is first choice, B is second choice, C is third choice)  
2: BCA  
3: CAB

There is an immediate and unresolvable problem. Two people (1, 3) rank A above B, and two people (1, 2) rank B above C. But that does *not* mean a majority prefer A to C. On the contrary, only one person (1) prefers A to C. In short, the majority voting system does not generate a *transitive* ranking.

**(b) Variety of Preferences:** If all individual preferences rankings are identical to each other, then there is no problem creating a social ranking. If all individuals agree on the same first choice, then there is no problem identifying the *social* first choice – even if the social ranking of other choices is uncertain. *But* when the individual preference rankings of voters are very varied, then that is when we can expect difficulties in achieving a social ranking.

What does 'varied' mean in this context? Suppose there are two voters and their individual preferences have a rank correlation of -1.

1: ABC  
2: CBA

---

<sup>10</sup> We see this clearly in British politics. Our two leading parties (Conservative and Labour) are happy to allow us to use a form of proportional representation for elections to the European Parliament. But both insist on retaining a 'first past the post' system for elections to the British parliament, and refuse to consider proportional representation.

Then there is a clear difficulty in achieving a social ranking. And consider the cyclical case:

- 1: ABC
- 2: BCA
- 3: CAB

Here the rank correlation coefficients between *any pair* of individual preferences is -0.5, and that makes for great variety in rankings. For, whichever choice is made (A, B or C), there will always be one voter who gets his last choice.

Suppose we measure the diversity of participants in a trading bloc by reference to their incomes, technological competence, comparative advantages, and so on. Then I venture to advance this hypothesis. *The more diverse is the group of participants in a trading bloc, the more diversity there will be in their preference rankings over standards, and hence the more likely it is we shall find difficulties in defining a social preference ranking for the group.* It would be very difficult to prove this, and perhaps it is only something that can be examined empirically; but I believe that very diverse trading blocs are likely to encounter problems of this sort.

Certainly some of the undecided countries – those that have not yet decided whether to join TPP – are concerned about the standards issues. Meltzer's report on the implications of TPP for India concludes (Meltzer, 2015, Section 7.1):

“...TPP standards will incrementally become de facto global standards. This is especially going to be true where TPP standards are also reflected in the TTIP. Access to TPP markets will increasingly require compliance with these standards and this will affect production processes globally. For India it will require exporters to conform to standards that may not be optimal for them.”

And an article in *The Diplomat* (2015) said of the implications for Malaysia (a country that has decided to join TPP): “Malaysia will also have to get its house in order if it is to accede to TPP standards.”

Two observations should be made in conclusion. First, in the political debate around TPP and TTIP, politicians sometimes make remarks like this (I paraphrase): “This project is going to happen, and it is the job of SDOs to make it happen.” But if the problems we have discussed above make it too difficult to design standards for a trading bloc, this is to ask SDOs to achieve the impossible. Perhaps we should conclude instead that the political project is too ambitious.<sup>11</sup>

Second, the Arrow theorem is sometimes called the Arrow paradox – though not, I think, by Arrow himself. But is it *a paradox*? In my view, it is not. We should hardly be surprised that it is difficult to agree a social choice in a society of very diverse voters.

## CONCLUSION

This short think piece has built on two earlier reports for a policy audience about the economics of standardization. It has focussed on four issues that were incompletely covered in those earlier reports.

---

11 The Financial Times (2015) also takes a cautious line about some features of TPP that it considers controversial. See Ernst (2014, 2015) for a broader discussion of these issues.

First, we will only develop a complete understanding of the economics of standards when we pool different experiences from different sub-branches of our discipline. In the same way, the SDO will only develop such an understanding when it involves a wide variety of players – including the former losers, as well as the former winners.

Second, the macroeconomic studies that evaluate the effects of standards on the economy depend on a black box model, and we need to open up that black box. We have argued that the linkages in that box have become more numerous and complex over the last thirty years, and that trend will continue.

Third, we argued that if the SDO is to develop a complete understanding of the winners and losers from standardization, and if standards are to fulfil their potential as instruments of economic coordination, then the SDO needs to evolve. In particular, it needs to involve a wider variety of players, including the apparent losers from standardization, and also the sectors of the economy that have not, to date, been represented at the standards table.

Finally, while it is essential to increase the variety of participants, this also brings its own challenges. Above all, we can expect to find ever greater diversity of interests amongst this wider community of SDO participants. In this context, the issues of social choice considered by the SDO become more complex. Arrow's famous *impossibility theorem* may have played a modest role in the study of SDOs, so far, but I expect it will become more important in future.

I suggest, in conclusion, that it is better that the SDO faces up to the diverse interests of its stakeholders, 'head on'. Rather than seek an artificial consensus by limiting membership, it is far better for the future of world trade, and equity in economic development, that these issues come to the surface in a genuinely integrative SDO.

## APPENDIX

This appendix is optional reading for those who would like a more formal explanation of some of the intuitive remarks made in Section 3 above. It is in two parts.

### *Maths of simple model from Section 3*

In this simple model, the members of a network interact and share knowledge to their mutual benefit. It was designed to model innovation in general, and common innovation in particular, but is applicable to a variety of other contexts – including SDOs.

The vector  $x$  describes the stock of knowledge that each network member has. The vector  $p$  describes the stock each member has before the network is formed. The stock then evolves over time ( $t$ ) according to what each member learns from the others:

$$x_t = p + Ax_{t-1} \tag{A.1}$$

If every interaction is positive,  $A$  is positive *definite*. If interactions are either positive or neutral, then

A is positive *semi-definite*. We are assuming, in effect, that the knowledge of one party which is of negative value to another is simply ignored by the latter.

When the knowledge has diffused around the network, then it will eventually settle down at an equilibrium level defined by the vector x:

$$x = (I - A)^{-1} p = (I + A + A^2 + A^3 + \dots) p \quad (\text{A.2})$$

Some readers will find it intuitively helpful to move away from the matrix notation, and examine how the original knowledge of one member (say h) impacts on the knowledge of another (say g). This can be written as a series of summations:

$$\frac{dx_g}{dp_h} = A_{gh} + \sum_{i=1}^N A_{gi} A_{ih} + \sum_{i=1}^N \sum_{j=1}^N A_{gi} A_{ij} A_{jh} + \dots \quad (\text{A.3})$$

Note that the third term in the above equation contains every element  $A_{ij}$  (for  $i = 1, \dots, N$ , and for  $j = 1, \dots, N$ ). This means that *every interaction* in the network plays a part, albeit a small part, in increasing the impact of member h's knowledge on member g. This property gives this model its essential character: all members of a network interact and share knowledge to the mutual benefit of all.

### ***Value of adding another member to the network***

Here we take one step further and ask, what is the value to the existing N members of a network if another member (N+1) joins. The following equation builds on equation (A.1): the N-vectors x and p refer to the original N members, while the scalars y and q refer to the new member (N+1).

$$\begin{pmatrix} x \\ y \end{pmatrix}_t = \begin{pmatrix} p \\ q \end{pmatrix} + \begin{pmatrix} A & b \\ c' & 0 \end{pmatrix} \cdot \begin{pmatrix} x \\ y \end{pmatrix}_{t-1} \quad (\text{A.4})$$

It is instructive to compare the solutions for x in equations (A.1) and (A.4) for  $t = 0, 1, 2$  and 3. These are given in the table below. The third column shows the differences between these. Given that all of the following: A, b, c', p and q are positive semi-definite, then we know that every term in the third column is positive semi-definite. From this we can deduce that x, the stock of knowledge for each original network member, reaches a higher level when an additional member joins the network – or, at the very least, the same level as when the additional member is absent.

As we follow the elements of the third column downwards from row 0 onwards, it becomes apparent that the expression in the third column is ever more likely to be positive definite. This means that it is ever more likely that a new member to the network will contribute, directly or indirectly, to the knowledge stock of original network members.

**Table A1**  
**Growth in Knowledge Stock with Network Participation**

	<b>Column 1</b>	<b>Column 2</b>	<b>Column 3</b>
	N members	N+1 members	Difference { <b>Col. 2 – Col. 1</b> }
<b>Row 0</b> t=0	p	p	0
<b>Row 1</b> t=1	p + Ap	p + Ap + bq	bq
<b>Row 2</b> t=2	p + Ap + A <sup>2</sup> p	p + Ap + bq + A <sup>2</sup> p + bc'p + Abq	bq + bc'p + Abq
<b>Row 3</b> t=3	p + Ap + A <sup>2</sup> p + A <sup>3</sup> p	p + Ap + bq + A <sup>2</sup> p + bc'p + Abq + A <sup>3</sup> p + Abc'p + bc'Ap + A <sup>2</sup> bq + bc'bq	bq + bc'p + Abq + Abc'p + bc'Ap + A <sup>2</sup> bq + bc'bq

This is important in view of the arguments in Section 3, where I suggested that original network members should be willing to subsidize the participation of new network members.

## REFERENCES

- Arrow K.J. (1963) *Social Choice and Individual Values*, 2<sup>nd</sup> Edition, Yale University Press
- Condorcet, Marquis de (1785) *Essai sur l'application de l'analyse à la probabilité des décisions rendus à la pluralité des voix*, Imprimerie Royale. <https://archive.org/details/essaisurlaplica00cond>
- Daimler Benz (1998) *Standardization 2010*, Daimler Benz AG: Research and Technology
- David P.A. (1987) “Some New Standards for the Economics of Standardisation in the Information Age”, in P. Dasgupta and P. Stoneman (eds.), *Economic Policy and Technological Performance*, Cambridge University Press
- Demski J.S. (1973) “The General Impossibility of Normative Accounting Standards”, *The Accounting Review*, 48: 718-723
- Diop N., J.C. Beghin and M. Sewadeh (2005), “Groundnut Policies, Global Trade Dynamics, and the Impact of Trade Liberalization”, in M. Ataman Aksoy and J.C. Beghin (eds.), *Global Agricultural Trade and Developing Countries*, IBRD/World Bank
- Ernst D. (2011) *Indigenous Innovation and Globalization: The Challenge for China's Standardization Strategy*, UC Institute on Global Conflict and Cooperation; La Jolla, CA and East-West Center, Honolulu, HI. <http://www.EastWestCenter.org/pubs/3904>
- Ernst D. (2013), *America's Voluntary Standards System – A “Best Practice” Model for Asian Innovation Policies?*, Policy Studies #66, March, East-West Center, Honolulu, USA <http://www.eastwestcenter.org/pubs/33981>

- Ernst D. (2014) “Trade and Innovation in Global Networks – Regional Policy Implications”, *East-West Center Working Paper*, Economics Series, # 137, May  
<http://www.eastwestcenter.org/publications/trade-and-innovation-in-global-networks-regional-policy-implications>
- Ernst D. (2015) “Innovation in Global Networks: The Challenge for Technical Standards and Related Policies”, Department of Commerce/NIST workshop, *Supply Chain Operations, Strategy, and Infrastructure Development in a Global Economy*, Georgetown University, May.  
<http://gsi.nist.gov/global/docs/training/2015/DErnstFINAL.pdf>
- Farrell J. and T. Simcoe (2012) “Choosing the Rules for Consensus Standardization”, *RAND Journal of Economics*, 43: 235-252
- Financial Times (2015) “TPP: Seven Things Worth Knowing”, *Financial Times*, October 12
- Henson S. and J.S. Wilson (eds. 2005) *The WTO and Technical Barriers to Trade*, Edward Elgar Publishing
- Hippel E. von (1988) *The Sources of Innovation*, Oxford University Press
- Hippel E. von (2005) *Democratizing Innovation*, MIT Press
- ISO (2010) *Action Plan for Developing Countries*, Geneva  
[http://www.iso.org/iso/iso\\_action\\_plan\\_developingcountries-2011-2015.pdf](http://www.iso.org/iso/iso_action_plan_developingcountries-2011-2015.pdf)
- ISO (2013) *Guidance on Twinning in ISO Standards Development Activities*, Geneva  
<http://www.iso.org/iso/pub100341.pdf>
- Lambert R. and P. Temple (2015) *The Relationship between Standards, Standards Development and Intellectual Property*, British Standards Institution.  
<http://www.bsigroup.com/LocalFiles/en-GB/standards/BSI-Standards-and-IP-2015-UK-EN.pdf>
- Meltzer J.P. (2015) *Standards and Regulations in the Trans-Pacific Partnership Agreement: Implications for India*, Draft Report, International Institute for Sustainable Development.  
<http://www.iisd.org/sites/default/files/publications/india-standards-regulations-ttp-agreement.pdf>
- Otsuki T., J.S. Wilson and M. Sewadeh (2001) “Saving two in a billion: quantifying the trade effect of European food safety standards on African exports”, *Food Policy*, 26: 495–514
- Simcoe T. (2012) “Standard Setting Committees: Consensus Governance for Shared Technology Platforms”, *American Economic Review*, 102: 305-336
- Swann G.M.P. (2000) *The Economics of Standardization*, Report for Department of Trade and Industry.  
<https://www.gov.uk/government/publications/standardisation>
- Swann G.M.P. (2010) *The Economics of Standardization: An Update*, Report for Department of Business, Innovation and Skills. <https://www.gov.uk/government/publications/standardisation>
- Swann G.M.P. (2014) *Common Innovation: How We Create the Wealth of Nations*, Edward Elgar Publishing
- Swann G.M.P. and R. Lambert (2016) “Standards and Innovation: A Brief Survey of Empirical Evidence and Transmission Mechanisms”, in K. Blind and R. Hawkins (eds.), *Elgar Handbook of Standards and Innovation*, Edward Elgar Publishing, forthcoming
- The Diplomat (2015) "What the Trans-Pacific Partnership Means for Southeast Asia", July 27.  
<http://thediplomat.com/2015/07/what-the-trans-pacific-partnership-means-for-southeast-asia/>
- Weiss M.B.H. and M. Sirbu (1990) “Technological Choice in Voluntary Standards Committees: An Empirical Analysis”, *Economics of Innovation and New Technology*, 1(1/2), 111-133