

Innovation for Sustainable Development

Jean-Yves Grosclaude

Executive Director, Head of Strategy, AFD (Agence française de développement), Paris, France

Rajendra K. Pachauri

Director General, TERI (The Energy and Resources Institute), TERI University, New Delhi, India

Laurence Tubiana

Director, IDDRI (Institute for Sustainable Development and International Relations), Paris, France

Damien Demailly

Coordinator New Prosperity Program, IDDRI, Paris, France

Raphaël Jozan

Project Officer, Strategy Division, AFD (Agence Française de Développement), Paris, France

Sanjivi Sundar

Distinguished Fellow, TERI (The Energy and Resources Institute), and Professor, TERI University, New Delhi India



Could innovation dwindle? Insights from the photovoltaic trade conflict

New energy policies and incentives are crucial for boosting innovation and scaling up the production of sustainable energy. In addition to environmental objectives such as mitigating climate change and reducing air pollution, governments also promote sustainable energy for economic and social reasons such as creating a manufacturing base for sustainable energy equipment and generating local jobs. Strikingly, sustainable energy policies encompass supply and demand-oriented measures which, for the most part, have trade effects that are likely to cause dispute due to their impairment or nullification of the expected gains from trade agreements of other countries. In the sustainable energy trade, what is at stake is the need for countries to agree on the appropriate balance of rights and obligations, allowing them to secure their policy space for sustainable energy innovation and deployment, while avoiding unfair trade competition.

The main issue addressed in this chapter is to what extent ongoing globalization patterns and trade rules allow for the kick-starting of a transformation towards sustainability. We focus on photovoltaic (PV) technologies and highlight the lessons that can be drawn from the so-called ‘solar trade war’ which has been unfolding between OECD countries and particularly between EU countries and China during the last five years.

The paper is organized in three parts. Part one briefly recounts the background to the competitive rush towards green technologies – also dubbed the ‘green race’ - and the rise of trade disputes over renewables that have occurred between the EU, US and China during the last five years. Part three reviews in greater detail the reasons

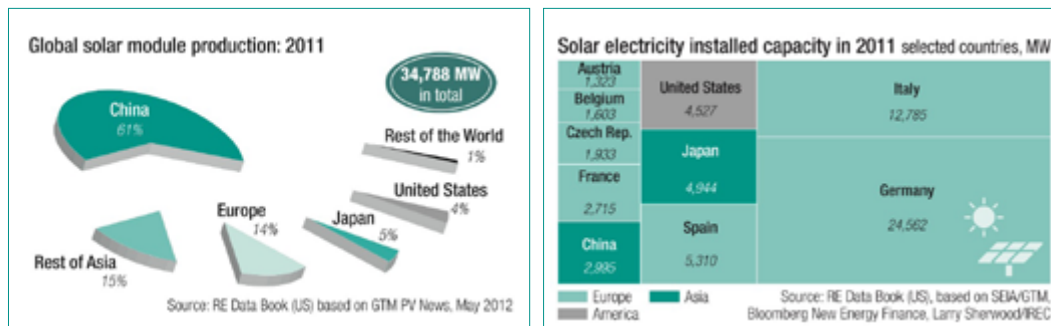
Tançrède Voituriez,

Associate researcher and Programme Director Governance at Cirad, Iddri, Paris, France

Xin Wang,

Research Fellow, Climate and Energy Policies – China at Iddri, Paris, France

FIGURE 1 Asian breakthrough in solar power



underlying the PV price collapses of 2009 and 2010 which triggered the solar trade war between the EU and China. Through the adoption of a European perspective, we delineate the problems with China's exports of PV panels and equipment to Europe. In part three, some weaknesses in the EU's arguments are highlighted and addressed. Part four focuses on what is really at stake for the EU in the solar war, which is followed by a conclusion that summarizes our main findings.

The green race between the EU, US and China

Among existing renewable energy technologies, the PV sector has achieved a spectacular development over the last decade, driven by a mixture of *push and pull* policies (*pull* in the EU and *push* in China) (WANG, 2013). Solar electricity generation has grown by a factor of more than nine between 2000 and 2011 (US Department of Energy, 2012) and is expected to continue to experience higher deployment rates than other renewable energies in the near future (IEA, 2012). China and the EU are the two leaders in PV production and deployment (Figures 1). The EU, and Germany in particular, leads in PV deployment while China and other Asian countries dominate the PV cell manufacturing market with nearly 77% of the global PV cell production in 2011. Interestingly, China's PV cell manufacturing was almost zero ten years ago.

A FRENCH PERSPECTIVE

In Autumn 2008, PV panel prices plummeted in the wake of the financial and economic crisis in the US. Dropping by a factor of four within a quarter, prices then fluctuated with erratic up-and-down swings around a general downward trend (Figure 2). EU and US political leaders have been vocal in their efforts to stop the profit drain associated with falling prices from damaging their domestic PV firms. In 2009, the US and EU kicked off investigations and consultation requests at the WTO against alleged dumping by China, while adjusting their Feed-in Tariffs (FIT) downwards. Booming imports of PV panels from China were also behind the revision of FIT policies and, in the case of France, the December 2010 moratorium

on public subsidies to solar energy. As acknowledged by the then French Environment Minister Nathalie Kosciusko-Morizet during the inauguration of the *Saint-Charles Solaire* solar central utility in the South of France in October 2011: ‘I agreed to come because this is French technology, together with cells from Germany, which are assembled in Luxembourg. There was an occasion where I refused to inaugurate a centre where they make Chinese panels’.¹ Attacking China for flooding the EU market and prompting the bankruptcy of EU crystalline PV module producers has been a constant theme of the French government ever since. ‘We need financial support towards the creation of jobs in France and not in China,’ were the words of Nathalie Kosciusko-Morizet, which are echoed by those of France’s Minister of Industrial Renewal Arnaud Montebourg today.

A EUROPEAN PERSPECTIVE

Similar sentiments have also been expressed in other leading PV module producing EU countries, although with less consistency and unanimity. In response to a complaint by the European ProSun coalition headed by the German-based Solar-World, which represents more than 25% of the EU’s total production of crystalline silicon PV modules and key components, in September 2012 the EU launched an investigation on the possible dumping of Chinese PV panels. The same coalition of companies also filed a separate complaint alleging that China’s producers had received unfair subsidies.² Other players in the sector such as the Alliance for Affordable Solar Energy (AFASE) – a coalition of 450 European companies – opposed the envisaged duties (47% at that time) on the grounds that these could have adverse consequences for downstream solar energy installers or importers.³

Along with intensive talks with China, on 6 June 2013 the European Commission (EC) imposed provisional anti-dumping duties on EU imports of solar panels from China. The duties were to be imposed in two steps, starting with 11.8% on 6 June and increasing to 47.6% on average on 6 August. On 27 July 2013, the EC announced its acceptance of an undertaking by Chinese manufacturers of solar wafers, cells and modules to fix minimum import prices for their products, with a volume cap to be imposed on Chinese solar exporters to the EU. The list of Chinese manufacturers signing up to the deal negotiated by the EC trade commissioner Karel de Gucht and his counterpart in the Chinese Ministry of Commerce (Mofcom) Gao Hucheng, included all the big names such as Yingli, Suntech, GCL Poly, JA Solar, Canadian Solar, China Sunergy, Hanwha SolarOne, Hareon, Jinko Solar and Renesola.⁴ The

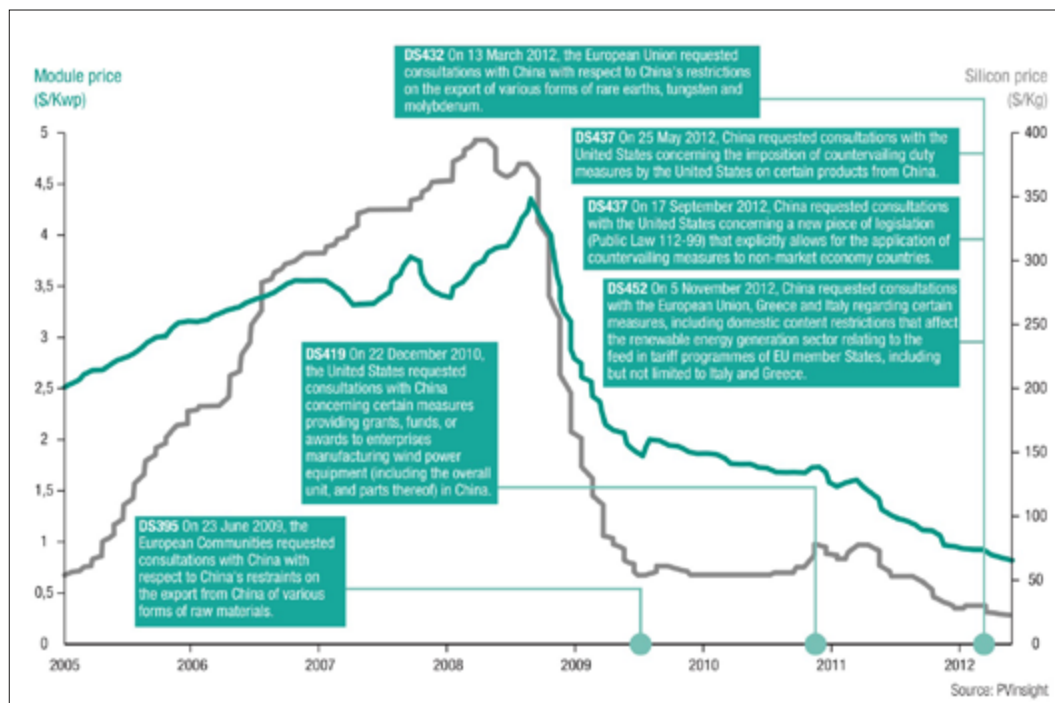
1. http://www.actupv.info/2011/10/saint_charles_solaire_ou_l_exemplarite_d_un_chantier_sans_lendemain-251878.htm#.UmZOmfnCzl

2. See: <http://ictsd.org/i/news/bridgesweekly/163186/#sthash.sqlTo0u8.dpuf>

3. ‘Punitive tariffs - no matter at what level - could cause irreversible damage to the entire European Photovoltaic (PV) value chain,’ AFASE said in a statement. ‘Those levels now reported would cost the EU PV industry and the whole of the EU economy dearly.’ (<http://ictsd.org/i/news/bridgesweekly/163186/#sthash.sqlTo0u8.dpuf>).

4. http://www.pv-magazine.com/news/details/beitrag/china-eu-solar-imports--to-cap-or-not-to-cap_100012250/#axzz2fngAxOAZ

FIGURE 2. A decade of disputes between the EU, the US and China on renewable energy



manufacturers included in the agreement would avoid paying anti-dumping duties on all their exports to Europe that fell under the volume cap. At the time of writing (September 2013), the EC was continuing the parallel anti-dumping and subsidy investigations, with a deadline for imposing definitive duties of 5 December 2013.⁵ Such investigations are superimposed onto a long series of disputes over renewable energy goods and equipment between the EC and US on one side and China on the other.

What is wrong with PV module imports from China?

THE EU ARGUMENT AGAINST DUMPING

On 6 September 2009, the EC launched an investigation to determine whether crystalline silicon PV modules and equipment imported from China were being dumped and whether the dumped imports had caused injury to EU industry. The *Notice of Initiation* of an anti-dumping proceeding issued by the EC stipulated that the allegation of dumping was based on a comparison of the normal value thus established with the export price (at ex-works level) of the product under

5. See http://www.pv-magazine.com/news/details/beitrag/ec-forgoes-punitive-duties-but-continues-anti-subsidy-investigation-against-chinese-importers--_100012312/#ixzz2foeJVjle

investigation when sold for export to the Union (EC, 2012). Since the EU considers the People's Republic of China (PRC) to be a non-market economy, the normal value for imports from the PRC were established on the basis of a constructed normal value (manufacturing costs; selling, general and administrative costs; and profit) in a market economy third country, namely India.

After the issuance of its Notice of Initiation, the EC sent questionnaires to a sample of Chinese exporting producers (representing 80% of the total Chinese export value); as well as to a sample of EU producers (accounting for, as a percentage of the total EU production, between 18% and 21% for modules, between 17% and 24% for cells and between 28% and 35% for wafers); a sample of three unrelated importers for modules and one for cells; and upstream and downstream operators and their associations. The Commission sought and verified all the information deemed necessary for the purpose of a provisional determination of i) dumping, ii) resulting injury and iii) EU interest. The results are shown below (EC, 2013):

For the sampled companies, the weighted average normal value of each type of the like product established for the analogue country was compared with the weighted average export price of the corresponding type of the product concerned. On this basis the provisional weighted average dumping margins⁶ expressed as a percentage of the Cost Insurance and Freight (CIF) Union frontier price, duty unpaid, ranged between 48.1% and 112.6%.

Against a generally increasing consumption, overall EU production increased for modules and cells in the period considered for investigation (1 July 2011 to 30 June 2012 – hereafter referred to as the 'investigation' or 'IP'). But the market share of the European Union industry shrank due to the greater increase of consumption. The EC concluded that the presence of Chinese imports and the increase of the market share of dumped imports from the PRC at prices that consistently undercut those of the European Union industry had a determining role in the material injury suffered by the European Union industry, 'reflected in its poor financial situation and in the deterioration of most of the injury indicators such as profitability, cash flow, return on investments and ability to raise capital' (EC, 2013). The investigation confirmed the existence of overcapacity in the global market and attributed it mainly to China.

Assessing the interests of the Union industry, the Commission provisionally concluded that there were no compelling reasons against the imposition of provisional measures on imports of the product concerned originating in China. The EC started by explicating the positive impacts of anti-dumping measures, emphasizing that the profitability of the Union industry would increase, and consequently that 'not only the existing 25,000 jobs of the Union industry would be secured but there would also be a reasonable prospect for further production expansion and increase in employment' (EC, 2013). Regarding upstream operators such as silicon and manufacturing equipment producers and exporters, the Commission acknowledged that they

6. The dumping margin is the amount by which the normal value exceeds the export price.

could face decreasing export prospects to China but that these could be compensated by the exports to growing third markets.

Independently of the imposition of duties, the EC also indicated that the publicly available forecasts on the demand for PV installations available during the IP indicated a likely contraction in demand in 2013, 'which would likely have in any event a negative impact on the number of jobs in the downstream market' (EC, 2013). It was therefore concluded by the Commission that the impact of the anti-dumping duties on the downstream operators would be to a limited extent negative in the short term, in view of the higher contraction in installations than in a counterfactual scenario without duties, and to the extent that the duty could not be fully absorbed by the downstream operators.

WEAKNESSES IN EU ARGUMENTS AGAINST DUMPING

In its Regulation of 4 June 2013, the EC stated that during the IP the sale prices of crystalline silicon photovoltaic modules and key components (i.e. cells and wafers) originating in or consigned from the PRC were below the production costs, thus having a negative effect on the Union industry's profitability (EC, 2013). However, the Commission did not fully elucidate why, out of all of the trade defence policy measures available in its portfolio, anti-dumping, instead of special safeguards, was deemed appropriate.

The choice of one defence instrument over another is not politically neutral. In the case of safeguard measures, a country acknowledges that it cannot cope with market price swings, whatever the underlying reasons of market imbalances. In the case of anti-dumping⁷, a culprit is singled out. In both situations, domestic industry is temporarily protected. Additionally in the case of anti-dumping, anti-competitive practices are corrected for. As mentioned above, Chinese practices – e.g. policies - were almost absent from the investigation. And the *amicable* solution found on 27 July 2013, according to De Gucht, which consisted in a price undertaking and annual import limits, did not make explicit the exact level of these two. One month after the amicable solution had been reached, no official price undertaking or annual import limits had been released. Pending the official release, the expected levels circulating in the media did not convince the complaining parties.⁸ As reported by PV Magazine, EU ProSun, the SolarWorld-backed lobby group that had worked hard to persuade the EC to take action against Chinese companies, remained dissatisfied with the end result.⁹

A related weakness in the EU's position lies in the choice of the reference market price – or 'normal value' of PV modules. Approaching the real cost of production

7. Under the World Trade Organization (WTO) Agreement, dumping is condemned but is not prohibited.

8. Once month after De Gucht's statement, the EU continued to decline to release specific details on prices and quantity limits. According to information found in the media, the minimum net import price for modules was €0.56 per watt, with an annual import limit of 7 GW; the net import price for cells was €0.29 per watt, with an import limit of 2.3 GW; and the net import price for wafers was €0.66 a piece, with an import limit of 1 GW (http://www.pv-magazine.com/news/details/beitrag/eu-china-deal-continues-to-irk-industry_100012444/#ixzz2gNOhfvqw)

9. http://www.pv-magazine.com/news/details/beitrag/eu-china-deal-continues-to-irk-industry_100012444/#ixzz2gNJZxzMY

of any product in a non-market economy remains fraught with difficulty; this said, the outcome of the EU's investigation makes it hard to claim that the normal value estimated by the Commission is the best estimate of the production cost in China. A careful reading of the Regulation document released by the EC reveals that the choice of the US as an analogue country was firstly made by the Commission – as in about half of the anti-dumping cases with non-market economies (EGGERT, 2006).¹⁰ The choice of the US PV price as a reference cost is debatable, as the EC itself admitted, 'mainly due to the fact that the US market was protected from Chinese imports during part of the IP by anti-dumping and anti-subsidy measures' (EC, 2013). India was eventually chosen. But the same criticism should have prevailed, in addition to a few others that we summarize below.

When the investigation was launched by the EU, the media reported that India was expected to set in motion an anti-dumping investigation into imports of PV modules into the country. According to the Indian Ministry of Commerce, India's solar manufacturers had called for anti-dumping duties as high as 200%.¹¹ Domestic manufacturers 'were struggling to survive under conditions of oversupply. They ha(d) not been able to compete with their global competitors on prices'¹² in spite of trade protection. For the product code CN 8541 40 (solar cells whether or not assembled in modules), the basic duty rate is nil in India, but add to this an additional countervailing duty (CVD) of 12%, a central excise education 'cess' rate of 3%, a custom education cess rate of 3% and a CVD special duty of 4%, which altogether amount to a duty rate equivalent of 17.24%. These duties complete domestic content measures (DCM) imposed on crystalline silicon (c-Si) solar cells and modules for projects under the National Solar Mission which aims to add 20 GW of solar power capacity to the country by 2022.

On 29 April 2013, based on an application from the Solar Manufacturers Association, India's Directorate General of Anti-dumping and Allied Duties (DGAD) initiated an investigation on imports of *solar cells whether or not assembled partially or fully in modules or panels or on glass or some other suitable substrates, originating in or exported from Malaysia, China PR, Chinese Taipei and United States of America*. Following this proposal, the US filed a request with the World Trade Organization (WTO) to intervene and protect the interests of American manufacturers. The Indian government subsequently challenged the American request at the WTO but was unsuccessful. India's PV manufacture sector, at the time when the EC chose it as a reference market, was hence both protected and – to put it bluntly – in bad economic shape.

In addition, two severe weaknesses must be highlighted. In the sample of the companies surveyed in India, only one provided a complete reply to the EU questionnaire.

10. For a Chinese perspective on EU 'analogy methodology', see Kong Qingjiang (2012).

11. http://www.pv-magazine.com/news/details/beitrag/indian-solar-manufacturers-ask-for-anti-dumping-duties-of-up-to-200_100008789/#ixzz2g6C6avi3

12. Id.

Furthermore, contrary to the Chinese companies involved, the Indian company did not produce solar wafers, which further complicated the establishment of normal value. First, this possibly led to an overestimate of PV module costs on the grounds that this company was unable to make integration-related cost savings. Second, it was not possible to estimate the price of a PV cell using the same methodology as for a module, therefore the prices of South Korean wafers on the Indian market were used. The overall impact being to bias upward the Indian PV price and along with it the estimated dumping margin.

Considering PV panel as a commodity

ASSESSING THE LEARNING CURVE EFFECTS IN PV PRICE DECLINE

An alternative hypothesis to deliberate dumping can explain the long lasting fall in PV module prices. Economic theory indeed isolates several forces likely to drive prices downward. Such bearish forces can be broken down into the two following sets (HAYWARD and GRAHAM, 2011):

- Experience curves, also called learning curves, relate production costs to the accumulation of experience, often measured by cumulative production. Experience curves are based on the theory of learning-by-doing, which asserts that ‘technical change in general can be ascribed to experience, that it is the very activity of production which gives rise to problems for which favourable responses are selected over time’ (ARROW, 1962). Due to learning and experience, encompassing factors such as technological change and economies of scale, the higher the amount of PV modules produced and installed, the lower their cost.
- Market forces come in two separate but related guises: the global market for the technologies themselves and the raw materials used in their production. Supply-demand imbalances can manifest as a price bubble on the top of the ordinary cost curve and/or a price dip if circumstances contrive to create a depressed market for the technology and its raw materials.

These two different forces presumably interacted in the case of PV, as upward and downward cycles along the learning curve tend to suggest.

Econometric estimates of the factors influencing price reduction in photovoltaics qualify the exact contribution of the different drivers underlying the learning curve. Nemet (2005) showed that economies of scale (plant size), technological change (efficiency gains) and the declining price of silicon were the main factors driving down the price of PV during the pre-bubble period (1975-2001).¹³ However, their learning curve model explains less than 60% of the change in price over the period considered, which means that non-learning curve effects must be taken into account to explain PV module price motion. De La Tour, Glachant and Ménière (2013) identified an experience curve model which minimizes the difference between predicted and actual module prices over the period 1990 to 2011. Their model predicts a 67%

13. We deliberately use *price* and not *cost* when discussing learning curve effects, the latter being discussed further below.

decrease of module price from 2011 to 2020. The authors derive from the learning curve's forecast value that the price of solar electricity would reach that of conventional electricity by 2020 in the sunniest countries or regions with annual solar irradiation of 2000 kWh/year or more, such as California, Italy and Spain. This learning curve effect on expected PV price does not, however, seem to properly account for the ongoing and rapid convergence of PV electricity price towards grid-parity in more than ten major markets worldwide – i.e. well before the 2020 date indicated by the authors.¹⁴

THE COMMODITIZATION OF PV PANELS

If learning curves provide only incomplete explanations for downturns in PV module prices, a further examination of the second set of bearish forces, namely global market imbalances, reveals more satisfactory answers. Such imbalances, manifested in price hikes and dips and temporary disconnections between the market value of a product and its marginal cost, are common features of primary commodities markets. Interestingly, they are usually considered as a rarity in the manufacture sector where operators are assumed to adjust margins to meet downstream demand at a stable price (WORLD BANK, 1994). This distinction between primary and manufacture markets – the former being intrinsically instable, the latter the opposite - has prevailed throughout the 20th century. However, it does not account for the blurring of the frontiers of these two classes of goods and the transformation of one class of product into another – something that has been dubbed 'commoditization'. A commodity (be it primary or manufactured) is a product that is completely undifferentiated. Commoditization occurs when a product becomes less differentiated, so that buyers care less about from whom they buy. The key effect of commoditization is that it reduces the pricing power of the producer: if products become more alike from a buyer's point of view they tend to buy the cheapest.

As pointed out by Graeme Pietersz (2013), commoditization is a key reason why many growth markets disappoint investors: sales volumes grow as expected but, as the market matures, prices come under pressure and margins shrink. The personal computer market and certain other types of computer hardware such as memory chips, which have oscillating prices around downward-sloped learning curves, provide a good example of this: 'When this was a fast growing industry each computer manufacturer would sell a computer together with a built in operating system, both of which were unique. Different manufacturers' products looked different, ran different

14. An unpublished Deutsche Bank research note hence asserts that 'The [PV] sector has passed the tipping point for grid parity in more than ten major markets worldwide and has the potential to achieve competitiveness in 10-20 additional markets over the next three years. As module prices stabilize around \$0.60-\$0.70/W, the levelized cost of solar electricity without subsidies is now 10-20c/kWh in several major regions of the world. Rising electricity prices, a need for competitive generation sources and lowered balance of system costs will drive further improvement over the next several years.' (quoted by James Montgomery, Associate Editor, RenewableEnergyWorld.com, <http://www.renewableenergyworld.com/rea/news/article/2013/08/analyst-grid-parity-era-now-underway-for-global-solar-markets>). Estimates of grid parity value are however biased towards renewable sources in most analyses, the fixed cost of electricity supply to end users (grid investment, distribution, stability, etc.) being incurred by historical suppliers of electricity (coal, gas, nuclear) and not to the most recent and complementary ones (e.g. renewables) for which only variable costs are inferred.

software and had very different capabilities. At this point the market attracted many growth investors as it was obvious that demand for the new technology was exploding. As the market matured two vital changes happened. The product became standardized, and therefore largely commoditized. In addition personal computer manufacturers largely ceased being significant producers of software — which is highly differentiated and commands huge margins'.¹⁵ This is very likely to have been the case in the PV module sector, where a 30-year-old technology (crystalline silicon) eventually commoditized the downstream manufactured good (the module and cells) (CHASE, 2013).

A temporary excess supply leading to plummeting prices is hence conceivable in the PV market, as it is in many commodity markets, such as computers, memory chips, cocoa beans, hogs and financial assets, without the involvement of dumping or subsidies. Commodity prices fluctuate randomly, to paraphrase Paul Samuelson (1963), and this randomness can generate unexpected downturns below the marginal cost. Interestingly, some interested parties consulted by the EC during the investigation argued that PV modules and equipment had become 'a commodity where individual producers are not able anymore to set prices but where prices are subject to world-wide demand and supply'. These interested parties alleged that it was this situation that had caused the material injury of the European Union industry rather than the dumped imports (EC, 2013). The investigation did not refute the fact – or assumption – that PV modules and equipment had become a commodity, simply emphasizing that this does not account for unfair price behaviour and trade practices.

Of course, should a large trading country set export subsidies or taxes, these could magnify the temporary disconnection between world prices and their competitive market equilibrium value. What remains obscure is the reasons why the EC chose a commodity with limited added value prospects – as commoditization implies – to flex its muscles against China. This is where political factors come in.

What is at stake in the solar war?

BALANCED TRADE AND MANUFACTURE JOBS

In 2012, the European Parliament issued a report, *Unbalanced trade?*, on EU and China trade, where it emphasized that 'trade between EU and China has been growing rapidly and continuously in the last three decades, reaching a peak amount of total trade of €395 billion in 2010, [...] the imbalance in bilateral trade has been in China's favour since 1997, this trade deficit amounted to €168.8 billion in 2010 compared to €49 billion in 2000.' The report further elucidates that: 'the value added to Chinese exports is very limited once the value of components imported from the EU and elsewhere is discounted; [...] foreign companies established in China account for nearly 85% of all export trade deriving from assembly operations' (European Parliament, 2012). The two parts of this quotation provide us with the possible primary

15. Graeme Pietersz (2013) Commoditisation, <http://moneyterms.co.uk/commoditisation/>

reasons for the EC's decision to stand against China on the grounds of anti-dumping, rather than to explore safeguards. To further explore this line of reasoning, we start by analysing the *unbalanced trade* aspect of the above quotation, before moving on to the part about the limitations to the value added to Chinese exports.

The fast increasing trade deficit of the EU vis-à-vis China on PV panels and cells has undoubtedly played a major role in the anti-dumping initiative from the EC's Directorate-General for Trade (DG Trade). The addition of the trade balances on silicon, wafers, PV panels, cells and inverters, reveals that EU trade averaged a yearly deficit with China of €10 billion between 2008 and 2011, to be compared with a trade surplus five years previously (Table 1). The magnitude and speed of this deterioration are reminiscent of the events that took place in the textiles and clothing trade following the expiration of the Multi-Fibre Arrangement in January 2005: there was a sudden and sharp degradation of the EU's trade position in relation to China.

Yet two salient differences remain: in the case of PV, there is no tariff cut or quota removal to explain the sudden upsurge of EU imports from China; while the symbolic value of PV modules and components - high-tech products of the 'third industrial revolution', the importance of which have been underlined by EC President José Manuel Durão Barroso¹⁶ - is definitely much higher for the EU than that of timeless knickers and bras. The emblematic nature of PV also crystallizes expectations of 'green job' creation in the EU, and hence of reversing the declining proportion of employment in EU manufacturing, which is a particular trauma in France regardless of the very limited support the PV industry has received from France so far.

The consequences of a higher (than dumped) PV price in Europe are not straightforward. One would expect some jobs to be saved in EU PV manufacturing as a result of EU anti-dumping measures, however, some could be lost among upstream operators facing decreasing export prospects to China, and also downstream among installers. Addressing this empirical issue, the EC (2013) cites a study by Prognos which predicts that out of the 265,000 estimated jobs that existed in 2011 at all

16. 'Europe's energy policy and the third industrial revolution', Loyola de Palacio energy conference, Madrid, 1 October 2007. http://europa.eu/rapid/press-release_SPEECH-07-580_en.htm.

TABLE 1 EU-CHINA TRADE, CUMULATIVE VALUE (IN EUROS MILLIONS)

	EU Imports from China	EU Exports to China	Balance	Yearly Average
C-Si (SH280461)	62.29939	1701.72	1639.42061	409.8551525
Wafers (SH381800)	1134.348	420.4735	- 713.8745	- 178.468625
PV Panels and Cells (SH 854140)	40812.062	793.6694	- 40018.3926	- 10004.59815
Invertors (SH850440)	787.5527	163.041	- 624.5117	- 156.127925
Total 11-14	42796.262	3078.904	-39717.358	- 9 929.340

Source of data : EUROSTAT

stages of the Union PV market including Union producers, importers, the upstream and downstream operators according to European Photovoltaic Industry Association (EPIA) (2011), up to 242,000 jobs would be lost in three years, depending on the level of duties. It is thought that most of the job losses would occur in the downstream market, which Prognos said employed about 220,000 people in 2011. The information obtained by the EC during a verification visit to the EPIA indicates that the number of direct PV jobs calculated for 2011 would have a margin of error of up to 20%. In addition, the estimation includes employment in other European countries outside the Union as well as employment related to thin film products, which falls outside the scope of the investigation. The investigation did not confirm the above scenario and pointed to a much lower number of direct jobs existing in the Union PV market in 2011, during the IP and in 2012.

IS CHINA CATCHING UP ON THE UPSTREAM EDGE OF THE SUPPLY CHAIN?

Here we move to the second part of the aforementioned quotation – the notion that overall ‘the value added to Chinese exports is very limited once the value of components imported from the EU and elsewhere is discounted; [...] foreign companies established in China account for nearly 85% of all export trade deriving from assembly operations’ (European Parliament, 2012). This rosy vision no longer holds, fuelling fears that China is catching up on the upstream edge of the supply chain.

The issue at stake can be looked at in the following way: do global market forces trigger and spread innovation today according to the way described in economics textbooks? Or is the *Samuelson syndrome* at work, whereby massive technology transfers/imitation to/in green technology-late-mover China leads to a real income

BOX 1. THE DIMINISHING RETURNS OF GLOBALIZATION

In a 2004 controversial paper¹, Nobel Prize winner Paul Samuelson sketched out the possible consequences of China catching up with the US in the very sector where the US enjoyed a comparative advantage – in other words, where it was leading the so-called green race. In his paper, this was supposed to happen as a result of technical innovation (‘imitation or home ingenuity’) and outsourcing. ‘What does [the] arithmetic tell us about realistic US long-run effects from such outsourcings? The new [...] productivities [levels] imply that, this invention abroad that gives to China some of the compar-

ative advantage that had belonged to the United States can induce for the United States permanent lost per capita real income’ (id.).

Forecasts on future investments in clean energy technology and anticipated trends in installed renewable energy capacity between the EU27, China and the US provide possible illustrations of the *Samuelson syndrome*: real wages in the sector concerned and potential overall real GDP could decline should China continue to catch up in green technologies and grasp an ever wider share of the value added in the supply chain. The problem here is not that renewable technologies

present salient features that companies and countries must consider while taking part in the green race, but that China and India tend to specialize in the very sectors or tasks where, historically, ‘Quad countries’ enjoyed undisputed comparative advantages when trading with one another.

Source: Voituriez and Balmer (2012)

1. Samuelson, P. (2004) ‘Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalization’, *The Journal of Economic Perspectives*, vol. 18, n° 3 (Summer, 2004): 135-146.

decline in green-technology first-mover countries, such as the US or EU (SAMUELSON, 2004; see also Box 1) and in turn, to dwindling innovation in the latter? If this was the case, then the division of labour advocated by China's Premier '(where) "designed in Europe" is combined with "made in China" and (where) European technologies are applied to the Chinese market' would no longer produce 'amazing results'¹⁷ due to a lack of activity in terms of 'designed in Europe'.

Without being explicitly mentioned in the EU's 2013 Commission Regulation or in the various statements of EU leaders, the Samuelson syndrome and its long-term devastating effect on EU productivity and growth may well have been in the minds of European leaders when they asked for punitive anti-dumping duties. But how close are we exactly to the world envisioned by Samuelson (2004)? Technology transfers have occurred on a massive scale between OECD countries and China, mainly through trade in intermediate goods. Over the last seven years, China has acquired production technologies to develop a high performing solar PV industry by purchasing turnkey production lines from German, US and Japanese suppliers and by recruiting skilled executives from the Chinese diaspora who built pioneer PV firms, according to De la Tour, Glachant and Ménière (2010). They are now able to manufacture their own production equipment (GLACHANT, DUSSAUX, MÉNIÈRE, DECHEZLEPRÊTRE, 2013), an area where US and German firms once enjoyed undisputed comparative advantage.

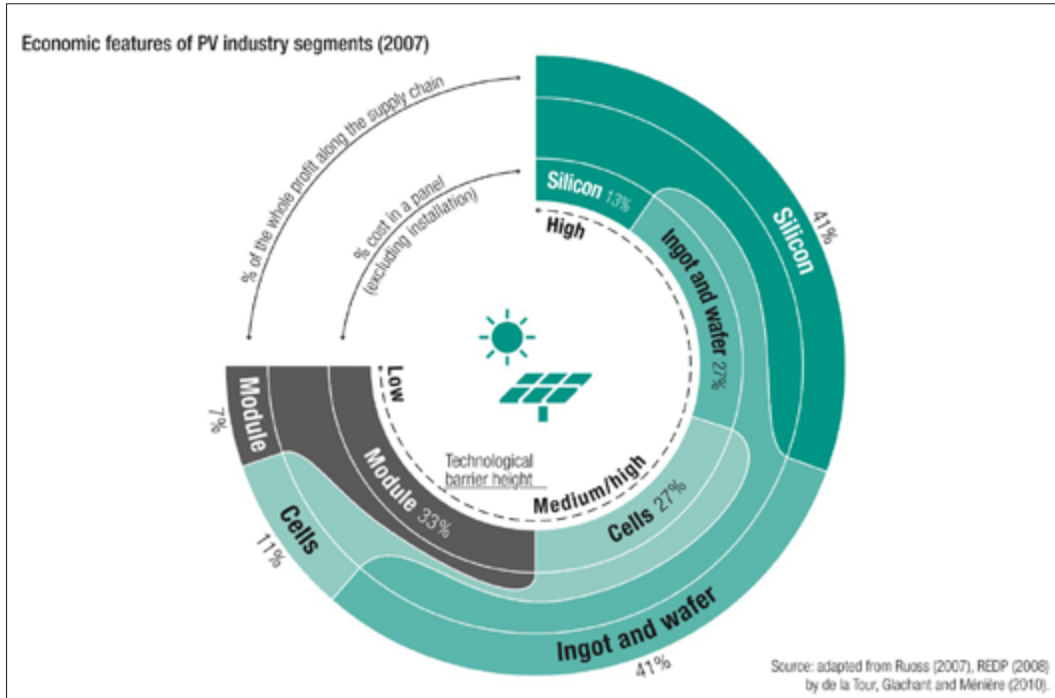
Moreover, the idea of a manufacturing China is not confirmed by the most recent patent data. Drawing on figures from the World Patent Statistical Database (PATSTAT), Glachant et al., (2013) provide us with a breakdown of climate-related patents by country. What becomes evident is that China is the only emerging economy in the Top 10, according to PATSTAT. Other major emerging economies or transition countries such as India, Russia or Brazil account for less than 1% of world innovation. The authors emphasize that other studies dealing with waste or green chemistry confirm the stylized facts. Figure 4 shows the shares of major countries in innovation patented worldwide, for each segment of the PV industry in the two years 2006 and 2007 prior to the crisis. China's performance is impressive: it indeed ranks third in all segments. Surprisingly, it leads with 37% of world patents in the silicon production segment for which its market shares are the tiniest. China's patenting activity is significantly higher in silicon production, ingot and wafer manufacturing than its contribution to world production (2.5% and 5%, respectively). The reverse is true in downstream segments. China is the second largest producer with a 27% market share (leader since 2008 with more than 35%) whereas it generates only around 15% of worldwide inventions.

What is the underlying strategy of Chinese companies? Do they intend to specialize further in upstream segments where the profits are the highest (Figure 3)?

Part of the answer lies in the *genuine innovative content* of patents and also in what's going on outside the patenting process. An often-used indicator to gauge

17. See footnote 2.

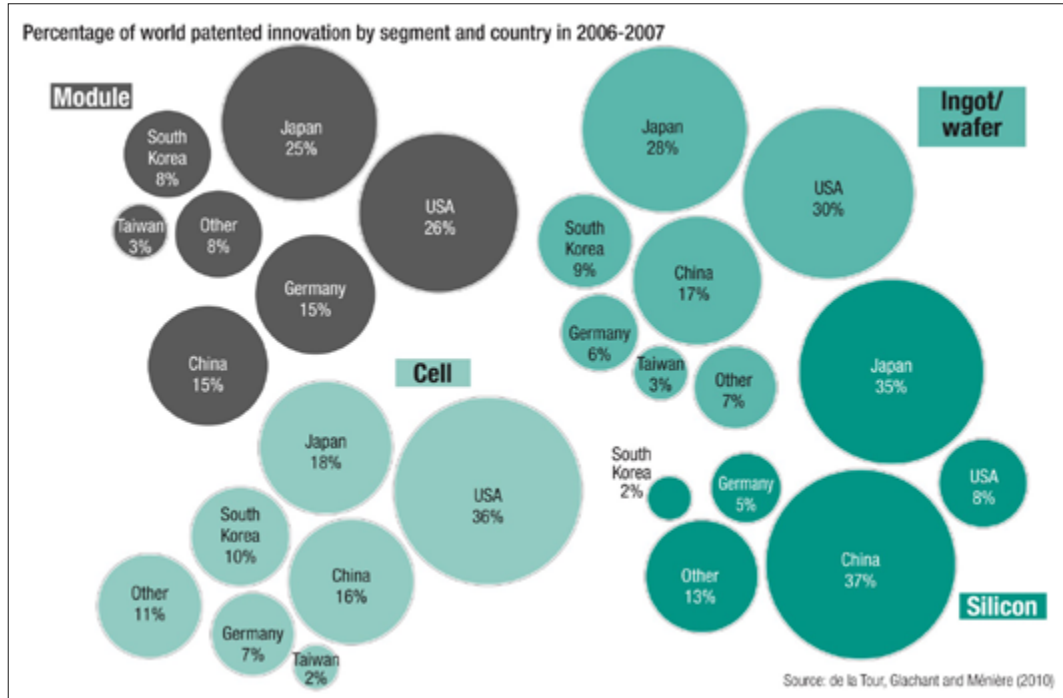
FIGURE 3 The manufacturing of value by the photovoltaic industry



The photovoltaic industry includes various products, the control and production of which do not generate the same added value. Today we are witnessing a repositioning of Chinese manufacturers in those sectors with high added value.

the genuine innovative value of patents is the share of patents that are also filed abroad. Only valuable inventions are patented abroad – for obvious cost reasons – while minor ones are patented on the domestic market only. Of course this way of gauging the value of a patent is far from perfect and open to debate, but it can be used as a rough guide. According to the screening of the PATSTAT database by De la Tour et al., (2010), only 1% of Chinese patents are also filed abroad, as compared to 15% for Germany, 26% for Japan and 7% for the US. This figure, the authors claimed, ‘reinforces the hypothesis that the value of the average Chinese patented invention is quite low’. They considered that this hypothesis is supported by the fact that Chinese firms devoted a low percentage of revenue to R&D (0.4% to 0.8%, while these figures are between 1.4% and 5% in western companies) (id.). Chinese companies, they concluded, ‘have a higher propensity to patent than their foreign competitors – they file more patent applications for an equivalent innovation

FIGURE 4 Actors of solar innovation



China has become a major player in solar innovation, ranking third in three of the four areas of innovation.

output.¹⁸ Going from this low patent value to the conclusion that Chinese firms do not innovate could be misleading, as the authors acknowledged. Their field work and interviews in China suggest that Chinese innovation focuses more on process, which is often not carried out in specific R&D departments but directly on the production lines, and protected by secrecy rather than patenting (id.). Even unconfirmed by comprehensive data covering patented and non-patented innovation in China, the Samuelson syndrome hypothesis cannot be rejected.

Conclusion

What lessons can be drawn from the ongoing solar trade war between the EU and China? Our basic argument is threefold. Firstly, the case of dumping put forward by the Commission and endorsed by a few ministers from EU countries is not fully convincing. Long-lasting downturns in prices that occasionally fall below the cost of

18. De la Tour, Glachant and Ménière (2010) carried out investigations in China which indeed confirmed that local companies were involved in the intensive patenting of minor inventions. Interestingly, they noticed that ‘the reason is not to protect the inventions – critical inventions are usually kept secret – but to send a signal to public authorities. In particular, the allocation of public subsidies by the National Development and Reform Commission (NDRC) is significantly influenced by the quantity of patents.’

production due to market imbalances is typical of commodity markets. The EC in its investigation was not able to reject the hypothesis that there has been a commoditization of PV panels, and neither can the authors of this chapter. This hypothesis was implicitly confirmed by the content of the temporary deal struck by the EU and China, which consisted of price floors and import quotas, which are historically genuine commodity market management devices. The acknowledgement that PV panels could be classified as commodities weakens the dumping probe and provides little support for the EU's decision to adopt anti-dumping measures for an undifferentiated commodity that, as commoditization implies, offers declining margin prospects.

Our second argument contradicts the reconciliatory view of China's Premier, according to whom, "When "designed in Europe" is combined with "made in China" and when European technologies are applied to the Chinese market, there will be amazing results".¹⁹ We contend that the division of labour in the PV supply chain is experiencing a profound reshuffling, whereby vertically integrated Chinese companies are gaining ground in the upstream value chain and there is a sharp increase in R&D expenses and patenting activities. Even though marginal in comparison with figures from the US, EU and Japan, innovation in China, be it genuine or not, could have the paradoxical effect of cooling innovation in Europe, rather than spurring it on, so long as the EU does not clarify the industrial objectives associated with its climate and energy targets.

Finally, we argue that the EU's objective to bring back Europe's manufacturing of crystalline PV modules could result in possible benefits in terms of upstream and downstream spillover effects, although we were unable to gather empirical evidence in support of this statement. In a similar fashion, bringing back PV manufacturing to Europe could be deemed as a necessary condition for sustaining PV innovation. Yet innovation spillovers remain elusive between *current* crystalline PV panel manufacturing and the development of the *next* PV generation. The solar war crystallizes technological catch-up by China on decades-old technology. What is at stake for the leaders of the green race, such as the EU, and for the mitigation of greenhouse gases, is not so much whether China is involved in dumping and the effect that this might have on commodity export prices, but how far the technology frontier can be expanded, and to what extent the manufacture of silicon PV modules can benefit this process. ■

19. Li Keqiang 'China has high hopes for European ties' Financial Times, 1 May 2012. <http://www.ft.com/intl/cms/s/0/f6911db2-92aa-11e1-b6e2-00144feab49a.html#axzz2fLpCvCj5>

REFERENCES

- BARBOSE G., DARGHOUGH N., WEAVER S. and WISER R., 2013, Tracking the Sun VI. An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012. Lawrence Berkeley National Laboratory, July 2013.
- BAZILIAN M., ONYEJI I., LIEBREICH M., MACGILL I., CHASE J., SHAH J., GIELEN D., ARENT D., LANDFEAR D. and SHI ZHENGRONG, 2012, Reconsidering the Economics of Photovoltaic Power, mimeo.
- BONY L., DOING S., HART C., MAURER E., NEWMAN S., 2010, Achieving Low-Cost Solar PV: Industry Workshop Recommendations for Near-Term Balance of System Cost Reductions.
- CHASE J., 2012, Breakthroughs in solar power, it's not just about technology anymore, Bloomberg New Energy Finance, powerpoint presentation.
- DE LA TOUR A., GLACHANT M., MÉNIÈRE Y., 2011, "Innovation and International Technology Transfer: the Case of the Chinese Photovoltaic Industry". *Energy Policy*, 39(2), pp. 761–770.
- DE LA TOUR A. and GLACHANT M., 2013, How do solar photovoltaic feed-in-tariffs interact with solar panel and silicon prices? An empirical study. Interdisciplinary Institute for Innovation, Working Paper 13-ME-04, April 2013.
- DE LA TOUR A., GLACHANT M. and MÉNIÈRE Y., 2013, *What cost for photovoltaic modules in 2020? Lessons from experience curve models*. Interdisciplinary Institute for Innovation, Working Paper 13-ME-03.
- EGGERT J., 2006, Observations on the Anti-Dumping Regulation. FTA Position for the Expert Meeting. Mimeo. Brussels, 11 July 2006. http://trade.ec.europa.eu/doclib/docs/2006/september/tradoc_129812.pdf
- EPIA, 2012, EPIA-market-report-2011, <http://www.epia.org/>.
- EUROPEAN COMMISSION, 2012, Notice of initiation of an anti-dumping proceeding concerning imports of crystalline silicon photovoltaic modules and key components (i.e. cells and wafers) originating in the People's Republic of China (2012/C 269/04), Official Journal of the European Union 6.9.2012.
- EUROPEAN COMMISSION, 2013, Commission Regulation (EU) No 513/2013 of 4 June 2013 imposing a provisional anti-dumping duty on imports of crystalline silicon photovoltaic modules and key components (i.e. cells and wafers) originating in or consigned from the People's Republic of China and amending Regulation (EU) No 182/2013 making these imports originating in or consigned from the People's Republic of China subject to registration. <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2012:269:0005:0015:EN:PDF>
- GLACHANT M., DUSSAUX D., MÉNIÈRE Y., DECHEZLEPRÉ-TRE A., 2013, Greening Global Value Chains. Innovation and the International Diffusion of Technologies and Knowledge. World Bank Policy Research Working Paper 6467, World Bank, Washington, DC.
- HOIUM T., 2011, The Most Important Cost in Solar. DailyFinance.
- ITRPV, 2012, International Technology Roadmap for Photovoltaics (ITRPV) Results 2011, CTM Group and SEMI PV Group, ITRPV.net.
- KERSTEN, 2011, PV learning curves: past and future drivers of cost reduction, Proceedings of the 26th European Photovoltaic Solar Hamburg 2011.
- KONG QINGJIANG, 2012, *China-EU Trade Disputes and Their Management*, World Scientific Publishing Co Ltd, Singapore.
- MAYCOCK, 2001, "The World Photovoltaic Market 1975-2001", PV Energy Systems, 2001.
- MEHTA, 2011, "PV News annual data collection results: 2010 cell, module production explodes past 20 GW", GTM Research, May 2011.
- MEYMANDI J. and CHIN S., 2013, UBS Investment Research Solar Industry Update, March 10th 2013.
- NEMET G.F., 2006, Beyond the learning curve: factors influencing cost reductions in photovoltaics, *Energy Policy* 34: 3218-3232.
- OECD, 2013, Interconnected Economies. Benefiting from Global Value Chains. OECD, Paris.
- PVNEWS, PROMETHEUS INSTITUTE & GREENTECH MEDIA, 2005 till 2010.
- REDP (China Renewable Energy Development Project), 2008, Report on the development of the photovoltaic industry in China (2008).
- RISTOW, 2012, Compilation of pricing and cumulated c-Si-PV installations based on data published in Maycock (2001), PVNews, Mehta (2011), and EPIA (2012), Alan Ristow, Photovoltech NV, Tienen, Belgium.
- RUOSS D., 2007, Global Photovoltaics Business and PV in Malaysia, Envision report
- SAMUELSON P., 2004, "Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalization", *The Journal of Economic Perspectives*, vol. 18, n° 3 (Summer, 2004): 135-146.
- VORTURIEZ T. and BALMER B., 2012, The Muddle over Green Race. IDDRI Studies 01/12 March.
- WORLD BANK, 1994, *Global Economic Prospects and the Developing Countries*. The World Bank. Washington. DC.
- YANG C.-J., 2010, Reconsidering solar grid parity. *Energy Policy* 38, 3270–3273.