

FREE TRADE: PANACEA OR POISON?

Mike Disney July 15 2017 [Version VII]

INTRODUCTION

All Britain's great industries have either closed down, or are in the process: coal, steel, ship-building, cotton-mills in Lancashire, woollen mills in Yorkshire; cars, motor-cycles,, bicycles, trucks, clocks and pottery in the Midlands; white goods, aircraft, computers, electronics.....going, going gone. Where did we go wrong? But it isn't just us. Youth unemployment in France is 25%, 40% in Italy and Spain. And look at America: its great manufacturing centres like Pittsburgh, Detroit, Cleveland, Baltimoreare now part of that broken rust-belt which rose in despair and voted for Trump. What have we all done to ourselves? Could it be that Free Trade, which academic economists proclaim is so good for us, is actually a poison?

As a scientist I have learned that when in doubt go and do the calculation for oneself. So that is what I do here. Either it is wrong, or it could be the key. It might be worth checking out.

The calculation demonstrates that:

- Free Trade in a wide range of commodities made a great deal of sense in the historical past when the main barrier to trade was transport cost.
- But Free Trade today only makes sense to the *importing nation as a whole*, IF the imported commodity in question is dramatically cheaper, at the point of retail sale, than its domestically produced equivalent. Yes Britain should continue to import bananas – but not cars or refrigerators. Imports can have large *Sunken Costs* arising from losses in domestic employment, investment and profit. None of us can afford to ignore such Sunken costs because we will *all* have to pay them in the end. Indeed we are paying them now. (This argument is carried out

in the British context of 2017, but it could as well apply to any advanced country.)

- Almost all trades between nations in the same geographical region, and at roughly equivalent stages of development, are destructive to the importing nations because the dramatic price advantages required to make it beneficial overall, simply cannot be generated. Thus the European Community, for example, in so far as it is a trading entity, is largely destructive to its members.
- The problem is this. Free Trade (FT) resembles morphine addiction. The gratification is immediate; the cost is postponed, or geographically remote, yet the pain will be suffered eventually, not only by the addict but by his /her family and fellow citizens. The gratification comes in walking out of the shop in London with a cheaper Asian shirt or dress. The pain will come later in the closing of factories and the destruction of jobs and lives in Lancashire. These are the Sunken Costs. It is to the benefit of a rich few to pretend they do not exist; to the dis-benefit of the vast majority who will, in the end, have to pick up the tab in the form of taxes for benefits for the disemployed.
- Drug addiction is a good analogy because only too much of FT is *self destructive*. It is not the Asians who are to blame for making apparently cheaper garments. There are vicious wars going on *within* nations between their cheap importers and their domestic manufacturers, but with the casualties, many serious, scattered the country wide. Wherever governments fail to settle such internal wars to the benefit of their citizens *as a whole* – then that nation will become sicker and sicker.
- The good news, the great news in fact, is that once we understand how to assess the nation's interest as a whole, and it isn't difficult, we can immediately

begin to put things right. There is no need to fear that the future is slipping out of our hands, or that our children's lives will be blighted; we just have to take back control. If we don't then the sickness can only get worse, become incurable and lead to economic and political death. As the transaction costs of more and more foreign trades fall, thanks mainly to the container-ship and the Internet, so the temptations to indulge the ghastly addiction will only multiply and spread. It's now!

- Why didn't economists point all this out before we damaged ourselves so badly? We will answer that question later but the fundamental problem is that the world can change faster than the minds of so called experts whose notions were largely fixed when they were students long ago. That can happen to any of us.
- In any case this matter is too vital leave to anybody else when we can think it through for ourselves, as I now hope to demonstrate we can.

N.B. We are not for a moment suggesting that *all* jobs lost in say manufacturing are due to cheap imports. Some will have been lost to increased automation, or changes in taste among consumers. We are concerned only with that fraction (roughly 3 out of 4) which *are* due to cheap imports and which we can therefore do something about. In some industries (e.g. textiles, electronics, white goods, cars... they will be a large fraction of the whole.)

N.B. If you see a little algebra don't faint; we are simply representing human quantities, for instance years, with symbols which will allow us to examine a very wide variety of cases by replacing those symbols with the numbers appropriate to each separate case; e.g. take $T = 10$ years for the UK now. This should be much simpler than filling in a tax return, but a good deal more important. After all this is a matter which could steal

away your entire working life – and the prospects of your children. Check it out.

2 ASSEMBLING THE FREE-TRADE TEST (FTT)

We want a test that will be:

- *Universal* in the sense it can be applied by any community to any commodity or service to find out whether it would be more beneficial to that community as a whole to import it, rather than produce it at home.
- Non-technical, *transparent*, and cast in human terms so that any one of us can apply it and interpret it without any danger of being bamboozled by ‘experts’ or confounded by rogues.
- *Comprehensive* in the sense that it includes all the important factors in an industry, including investment, profit, labour, raw materials, ancillary component supply.....and so on and so on, but above all the human need to work, earn and be independent.
- *Time-independent*, as applicable to the future as it will be to the past and present.
- *Inclusive* of relevant factors such as exchange rates and inflation, preferably without having to mention them specifically.

These demands amount to such a tall order that one despairs of ever meeting them – I did. But happily, at a very small cost, we can. That cost lies in phrasing the test in symbols such as T and f_x . By giving those symbols different numerical values we can then, as we claimed, explore a wide world of applications. Call it algebra if you like; here it amounts to no more than symbolic arithmetic. If you lose the thread just carry

on and use the test, then go back when you have more sense of what is going on: we scientists have to do that all the time.

N.B. Some who have read this article, and strongly agree, have urged me to ‘leave out the maths’. But that would be to fall back into the very trap we have got ourselves into. We fell headfirst into it because our ruling classes couldn’t count; can’t count. We can only climb out of it by counting the costs for ourselves. They got away with their sloppy ill-educated kind of ‘leadership’ precisely because they relied on us not being able to think any better for ourselves. Well we can; we need to; and we will.

The fundamental requirement of the test for any importing country can be stated in words:

“The anticipated savings from importing commodity X, accumulated over T years, must exceed the anticipated losses in the domestic X-industry including: capital invested in the manufactory and supporting infrastructure; the profits forgone over that period; and the livelihoods of the resulting disemployed who will need support to get back on their feet.”

For the moment we will work in units of Value-added by the domestic X-industry per annum (which we symbolize by V_{pa}). This saves us from having to worry about related factors such as raw materials and component suppliers [which, if so desired, can have the same test applied to them separately].

The measure of instant gratification afforded by the import will be f_X the factor by which X will appear cheaper to purchase *at a domestic retail unit*, than its domestically produced equivalent. Thus if an imported X were 25% cheaper than a home-made X f_X would be 0.25.

We start crudely, and refine later.

Then for the imported X to benefit the importing nation as a whole (i.e. for the statement in italics to be true):

$$f_X V_{pa} T > I_0 + p V_{pa} T + WC_w \quad (A)$$

The Left hand side is the total gratification accumulated over T years; $>$ is the usual symbol for “must be more than”; I_0 is capital invested in the domestic X-industry; p is the annual net profit as a fraction of the Value-added V_{pa} (if it is 9% $p = .09$). W is the number of employees (Workers hence the W) who will be made redundant when their industry closes, and C_w is the average redeployment cost for each, to return them to their former standard of living when they were making X. Both the gratification and the profit-lost would accumulate over the years whereas the capital and redundancy costs are one-off. So to benefit one has to do the sum over some pre-specified time interval T during which the terms-of-trade can be presumed to remain fairly stable. T we call ‘The Turnover-Time’ or ‘Churn-time’.

Now we wanted everything in terms of timescales and we can progress in that direction by writing $I_0 = V_{pa} \times T_0$ (i.e. the start-up investment cost I_0 corresponds to T_0 years of annual value-added.) Likewise we can write $C_w = T_w \times I_w$ i.e. by valuing the compensation per employee in terms of T_w years of his or her income I_w . Then we can rewrite (A) :

$$f_X V_{pa} T > T_0 V_{pa} + p V_{pa} T + (W I_w) \times T_w \quad (B)$$

We can simplify (B) by noting that the industry must generate a net annual profit $p V_{pa}$ where:

$$p V_{pa} = V_{pa} - \frac{V_{pa} T_0}{T_D} - W I_w \quad (C)$$

where $W I_w$ is the annual wages bill and the penultimate term is the annual sum that must be set aside to pay off the start-up investment [$I_0 = V_{pa} \times T_0$] to be repaid to the bank over T_D years. [T_D is called the ‘Discount Time’, or the reciprocal of the discount-rate imposed by the lending bank. If that rate is 10% , or 0.1, then $T_D = 1/0.1 = 10$ years. Simple.]

If we rearrange the last equation:

$$WI_w = V_{pa} \left(1 - \frac{T_0}{T_D} - p \right) \quad (D)$$

we can use it to replace the WI_w in (B) when:

$$f_X V_{pa} T > T_0 V_{pa} + p V_{pa} T + V_{pa} \left(1 - \frac{T_0}{T_D} - p \right) T_w$$

and as V_{pa} now appears in every term we can cunningly cancel it out leaving:

$$f_X T > T_0 + pT + \left[1 - \frac{T_0}{T_D} - p \right] \times T_w \quad (1)$$

which looks like the test we wanted. It contains only timescales (T , T_D , T_0 and T_w , in years) and pure numbers (the fractions f_X and p). We shall call it the ‘Free Trade Test’ or FTT. Translated into words it simply says “ *The benefit of cheaper prices over time (i.e. $f_X T$) must exceed ($>$) the Investment lost (T_0), the profits forgone (pT) and the redeployment costs (T_w) of the number of workers [proportional to the square bracket] dis-employed by choosing cheaper imports instead.*”

To see how easy the FTT is to use, and to check that it makes rough sense, let us look at some crude numerical examples:

(i) In the slow changing pre-Victorian world ($T=30$ years say) discount rates were naturally low too ($T_D = 30$ years as well), industrial plant was unsophisticated ($T_0 = 1$ year), workers were largely unskilled and un-empowered ($T_w = 1$ year) while annual profits might have been much as today i.e. 10% ($p= 0.1$). Then the FTT would read:

.....

$$f_x \times 30 > 2 + (0.1 \times 30) + \left(1 - \frac{1}{30} - 0.1\right) \times 1$$

or $f_x > 0.19$ or 19%.

Thus in those days so as long as any imported commodity X could be sold 19% cheaper in the shops than its domestic equivalent, it would have benefitted the importing country as a whole. What discouraged trade then was the enormous cost of bringing products from far afield so that trade was largely confined to luxuries such as spices, bullion, silk and slaves.

(ii) In the much faster changing modern world a modernised version ($T_0 = 2$ years of investment instead of 1, see Section 4 later) of the same industry with $p=0.1$; $T_w = 1$ year as before) would have to be much faster on its feet ($T = T_D = 10$ years now). The FFT would now read:

$$f_x \times 10 > 2 + 0.1 \times 10 + \left(1 - \frac{2}{10} - 0.1\right) \times 1$$

or $f_x > 0.37$ or 37%, a significantly higher hurdle for potentially beneficial imports to surmount.

(iii) But in a relatively advanced nation such as modern Britain (ii) is still unrealistic because profitable industries will tend to be much more sophisticated i.e. capital-intensive so with $T_0 = 4$ years instead of 2, and their employees better trained (and therefore costly to redeploy so $T_w = 3$ years say instead of 1) in which case the FTT) requires:

$$f_x \times 10 > 4 + 0.1 \times 10 + \left(1 - \frac{4}{10} - 0.1\right) \times 3$$

or $f_x > 0.65$ or 65%.

Between the pre-Victorian era and today the entire trading outlook has changed dramatically, principally because the commercial world has speeded up. Certainly Transaction costs such as transport costs have fallen spectacularly – but at the

same time the *Submerged Costs* of importing cheap goods (in capital destroyed, profits forgone and livelihoods lost) have, if properly calculated, risen even more spectacularly.

Just think on one startling consequence of the last example. Even if it is only roughly right then it is debilitating to import X's from any nation at approximately the same state of development as our own, and with no striking natural advantages (e.g. in geology or climate). Thus most of the trade within the European Community is destructive to the importing nation. This is the very converse of what economists have been preaching at us for fifty years.

4 INCLUDING REINVESTMENT

But let's move on because even (iii) underestimates the true sunken costs of FT since it ignores re-investment by the industry itself, to say nothing of the human and governmental costs of re-locating employees – if they are to be found equally rewarding jobs. And why not?

If they are to remain competitive firms need to continually re-invest. If the firm then fails, due to cheaper foreign imports, that accumulated re-investment will largely be wasted too. Which can only swell the costs of the prospective import trade.

Suppose an industry re-invests each year a fraction r of its value added then (B) must contain an extra term $rV_{pa}T$ on the Right Hand Side.

But that re-investment will annually detract from the net profits so that (C) becomes

$$pV_{pa} = V_{pa} - \frac{T_0 V_{pa}}{T_D} - rV_{pa} - WI_W$$

so (D) will become

$$WI_W = V_{pa} \left[1 - \frac{T_0}{T_D} - (p + r) \right]$$

and so finally the FTT (1) must be refined to read:

$$f_x T > T_0 + (p+r) + \left[1 - \frac{T_0}{T_D} - (p+r) \right] \times T_w \quad (2)$$

which is identical with Equation (1) except that p is replaced by $(p+r)$ everywhere. In general re-investment can only lift the bar on f_x . For instance in example (ii) above a reinvestment rate of only 0.1 (10%) raises f_x to 0.72, or to 72% from 65%.

But do not forget that plant also wears out. If the re-investment rate is no greater than the wear-out (depreciate) rate then it turns out that the r in (2) should be zero.[More generally the r in (2) should be $(R \text{ minus } w)$ where R is the gross reinvestment rate and w the annual depreciation rate, so that r is net of the two.]

So (2) is a more precise version of the FTT than (1).

4 HOW MUCH IS AN EMPLOYEE'S LIVELIHOOD WORTH?

We denote that by T_w , the number of years income-equivalent that employees made redundant will require in support to restore them to the labour market at their former standard of living.

There are many components which go to make up T_w , especially in a nation which considers itself skilled and civilized. For instance:

- T(income): the immediate loss of income that may follow dismissal.
- T(retraining): the costs, and years of support, required to retrain the employee to the same level as before. This will depend on individual accumulated skills.
- T(relocation): the costs of re-location, if that proves necessary to find employment of equivalent quality.

N.B. T(relocation) can itself be complicated and have several components of its own which might include:

- T(housing): the cost of selling a house in a community which now has more unemployment, and purchasing another in a community which necessarily must have less.
- T(partner): the cost of one's employed partner having to give up their job too, and find another equivalent job elsewhere.
- T(Human): the cost to the whole employee's family of losing their friends, local family members (e.g. grandparents) and their supporting networks. Do not underestimate the pain involved. I dragged my own family around the globe and witnessed their pain at first hand -- several times. For instance never drag a teenager away from the friends who mean so much to them at that age. We met a lady in Ohio, the wife of an executive at Macdonalds, who had been forced to move no less than 21 times as her spouse moved up the company promotion ladder. She told us that she had no friends, no social life, no meaningful job, no children within 2 hours (they'd all dropped off along the way), not even furniture of her own because it would have had to move around the US at an average speed of about a thousand miles a year.
- T(Infrastructure): Where there is employment, especially of the long standing kind, both government and private commerce invest capital to service the local families involved: roads, schools, shops, hospitals, sewers, electricity, churches, entertainment....on and on and on. If a large segment of the working population moves out much of that infrastructure will have been wasted.

Probably the best way to evaluate all these components is to imagine yourself the employee made redundant. Maybe it was

cotton weavers or coal-miners yesterday. Tomorrow, so the prophets say, it could be almost any one of us. Here, for what it is worth, is my own tentative estimate for a moderately skilled British employee with a fully employed partner, a home (with the mortgage half paid off), two children doing OK at school and hoping to stay on until 18, who all have to relocate:

T(income): 1 year

T(retraining): 2 years retraining costs.

T(housing) : 1 year (local house sold and another equivalent bought within a higher cost area).

T(partner) : 2 years. Partners job lost, also requiring re-training.

T(Human): 3 years. The human cost to the family.

T(Infrastructure) : 1.5 years for local infrastructure now unnecessary.

Which all comes to a grand total of about $T_w = 10$ years. Factor that into case (iii) above and we have:

Case (iv): $T = T_D = 10$ years, $T_0 = 4$ years; p and r both 0.1 (10 %) and we are left, according to the FFT (2) with:

$$f_x \times 10 > 4 + 0.1 \times 10 + 0.1 \times 10 + \left(1 - \frac{4}{10} - 0.1 - 0.1\right) \times T_w$$

$$f_x > 0.4 + 0.1 + 0.1 + (0.4)$$

which comes to 1.0 or 100%!

In other words the imported X would actually have to be given away FREE at the point of retail sale for the community as a whole to benefit. The costs of instant gratification may be submerged, but they could sink us all in the end.

One can certainly argue over all the components of T_w , but at the close of the day the details don't much matter because the implications remain much the same. Advanced countries in particular should not import any commodities without first assessing the sunken costs. It may be far better to produce them at home.

5 HOW MUCH CAPITAL IS INVESTED (i.e. T_0)?

Beside T_w the parameter which distinguishes one industry from another in the FTT is T_0 the amount of capital invested in the business in years of Value-added. The UK Office of National Statistics has tabulated T_0 (in years) for various industries in the UK as of 2013 and here is a selection taken from their table 12¹:

INDUSTRY	T_0
Scientific and Technical	0.5
Other Service activities	0.7
Finance and Insurance	1.0
Health and Social Work	1.0
Wholesale, Retail, Motor repair	1.1
Education	1.3
Manufacturing	1.6
Accommodation and Food	1.7
Mining and Quarrying	2.7
Admin and Support	3.0
Arts, Entertainment and Recreation	2.8
Construction	3.0
Public Admin and Defence	4.2
Transport and Storage	4.4
Electricity, gas, steam, air	4.5
Agriculture, Forestry and Fishing	6.4
Water, Sewage, Waste-Treatment	6.8

For UK *manufacturing alone* the ONS published a very readable article² full of statistics relevant to the FTT, out of which I pick a few:

¹

<https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/bulletins/capitalstocksconsumptionoffixedcapital/2>

² “The Changing Shape of UK Manufacturing, 2013, Hardie and Banks.

- a) Hourly wages rise in proportion to value-added per hour and are almost exactly half of it (their Fig 1).
- b) A ‘typical’ manufacturing worker (in so far as there is one) produces £50,000 worth of VA per year, using about £100,000 of capital invested.
- c) Over the past 60 years labour productivity has risen by 500% in manufacturing, but only 150% in Service industries.
- d) There have been huge job losses between 1979 and 2013 by industry (fig 5) as follows:

Textiles, Wearing Apparel and Leather goods	87%
Computers, electronic and electrical goods	68%
Transport Equipment	65%
Basic metals and metal products	60
Manufacturing in general	60
Machinery and equipment	60
Food, Beverages and Tobacco	45
Wood, paper products and printing	42

Some of those job losses are due to increasing productivity but most must be the consequence of imports. Taking into account the doubling of GDP over this same period but an increase in productivity of about 170% one infers that roughly 3 out of 4 jobs lost – with an even higher fraction in manufacturing, must be due to cheaper imports. This may be rough but it does show how dramatically FT is affecting employment and job prospects. Where will it end?

- e) Labour quality (in terms of training and Qualifications) increased between 1993 and 2013 by between 5 and 25% depending on sector (fig.7)
- f) There has been a significant ‘deepening in capital’ [Fig 13] i.e. more capital invested in manufacturing per hour worked between 1997 and 2012, and a concomitant rise in in Value added per hour; i.e. T_0 rose as time passed, roughly doubling in only 15 years.

NB Many of the above figures are parochial to the UK but they are probably typical of any first world nation, and adequate to sustain our main points in a wide variety of areas (see below).

6 USING THE FREE TRADE TEST (FTT).

In a fast changing world everyone's niche in the job market is at risk. That vast container ship sneaking up the channel full of cheap imports may tip you out of yours. Thus we all need the means to scrutinize potential import trades to assess how threatening they are. The FTT is an instrument (albeit imperfect) devised to help ordinary citizens do just that. Here are a few general tips to make the best use of it:

- There are winners as well as losers in FT. Everyone knows of high street vendors who have pocketed vast fortunes out of importing cheap goods, bought knighthoods, then scuttled off to Caribbean tax havens leaving the rest of us to shoulder their submerged costs. There is no point in blaming them; parasitical worms exist everywhere. But alert communities can prevent them from consuming their society alive. We have to make the appropriate calculations, i.e. employ the FTT, then vote for politicians who can learn and steer clear. We need to be certain of our estimates because you can be sure there will be powerful, and vocal vested interests, probably with tentacles into the government, who will resist like hell. Who owns your daily newspaper?

- It's our future, and our childrens' future too. So when in doubt we ought to lean always towards caution in choosing values for the various T's. After all we can as a nation always change our minds about X and start importing it tomorrow, whereas it might take years to recover from the attendant human losses if an FTT proves too heedless of Submerged costs. In that spirit I would urge a value for the Overturning- or Churn Time T of no more than 10 years. The one certain fact here is that *the world is speeding up* to the point where no one today can reliably predict the terms-of-trade more than a decade ahead (for instance the average US

business lasts less than 10 years). In that case the FTT simplifies to:

$$f_x > \frac{T_0}{10} + (p+r) + \left(1 - \frac{T_0}{T_D} - (p+r)\right) \times \frac{T_w}{10} \quad (3)$$

- Assume $T_D = T = 10$ years. Why? Because investors who lend money to business must have a reasonable expectation of getting it back. They too must worry about churn. Lending 40 years ahead in a world overturning in 10 is generally a mug's game. It is probably no accident that historically Discount times (T_D) and Turnover times T seem to have roughly tracked one another.

- What about p and r ; what can be said about them in general? As you will recall when $r = 0$ the business will just be ticking over, repairing wear and tear, but no more. Positive values of p or r signify positive gains for the entrepreneurs who started the business, p in the form of annual dividends, r in the form of accumulating share-value. They can take their gains out either way but what we cannot expect is for $(p+r)$ to become either too high or too low. If $(p+r)$ rises much above 0.15 (15%) eager competitors will rush in to partake of the honey and so drive $(p+r)$ back down again. If $(p+r)$ falls much below 0.05 (5%) investors might as well take their money elsewhere where it could earn more. So, lacking better information, commercial practice suggests we won't go too wide of the mark if we assume $(p+r) = 0.1$ (10%). With all of the above approximations the FTT reduces to

$$f_x > \frac{T_0}{10} + 0.1 + \left(0.9 - \frac{T_0}{10}\right) \times \frac{T_w}{10} \quad (4)$$

a sum one can practically do in one's head. For instance were $T_0 = 3$ and $T_w = 4$ years:

$$f_x > 0.3 + 0.1 + (0.6) \times 0.4$$

$$f_x > 0.3 + 0.1 + 0.24 = 0.64$$

where one can see, for the case of X only, the separate costs to investment (0.3), to profit (0.1) and to manpower (0.24).

[Those who prefer to work in percentages can multiply (4) throughout by 100 when:

$$f_x(\%) > 10T_0 + 10 + (9 - T_0) \times T_w \quad (5)$$

whereupon, if $T_0 = 3$ years and $T_w = 4$ as above:

$$f_x(\%) > 30 + 10 + (9 - 3) \times 4 = 64\% \text{ once again.}]$$

- The most problematical step in using the FTT is choosing a value for T_w , the years of support that the community as a whole should give an employee (including family) displaced by a communal decision to import certain cheap goods. It is problematical because it requires both imagination and empathy – neither of which qualities are widely guaranteed. It would be all too easy for an accountant in Basildon to underestimate the suffering experienced by an unemployed coal miner and his family in Bargoed. And vice-versa of course. The only remedy I can suggest is that we should all ‘do as we would be done by’, a maxim more than appropriate nowadays when technology could displace us almost all. Imagine you have just been dispossessed of your livelihood, have to be retrained from scratch, and then have to sell your home and move far far away with your family to get suitable re-employment. What could you reasonably hope for in support from your fellow citizens, given that redundancy was no fault of your own, and that they have benefitted in consequence? And when you have drawn up that wish-list apply the same consideration to your fellow citizens (appropriately adjusted for their relative levels of skill). I suspect we will then find that our T_w s, the values we put on

other people's working lives, as well as our own, will rise significantly.

- Note that the FTT is defensive and not aggressive because all its parameters are *internal* to the nation which is using it. It is simply asking 'Do we want to make this commodity or don't we?'; it is not concerned with trade wars or robbing other countries, but simply with nurturing one's own. Every country can and should apply it to themselves, and afterwards use tariffs to protect their people at large. Unfortunately the terms 'Tariff' and 'Protectionism' have become dirty words over the course of Economic history; and understandably so when such tariffs have been used to protect the undeserving rich at the expense of the starving poor [as in post-Napoleonic Britain when the Corn Laws forced 30% per cent of its population to chose between emigration or the workhouse]. But history has moved on; rationally imposed, such tariffs should be called 'Importers Taxes' for that is what they are. They are imposed to see fair play; to see that importers don't get away with undeserved fortunes by dumping the sunken costs on their fellow citizens. We shall call them 'Fairplay' Taxes' henceforth.

In summary: there are several versions of the FTT the Free Trade Test to choose from [Tests labelled from (1) to (5).] (1) is the crudest, (2) the most general; the last three are increasingly simplified and more approximate versions of (2) designed for easy use. If you feel you can handle only one then use version (5) because it is the shortest to use and easiest to memorise (which could be useful). It will certainly be more use to most of us than $E = mc^2$. And if you don't want to calculate the arithmetic each time here it is in table form. Each industry is characterised by two numbers (in years) T_0 and T_w , the first denoting the amount of investment in it, the second the degree of skill in its workforce, which together yield $f_x(\%)$, the requisite import hurdle.

TABLE OF $f_x(\%)$ IN TERMS OF T_0 AND T_w
(for $T = T_D = 10$ years and $(p+r) = 10\%$)

T_w	1	2	3	4	5	6	7	8	9	10
Years										
T_0										
1	28%	36%	44	52	60	68	76	84	92	100
2	37%	44%	51	58	65	72	79	86	93	100
3	46%	52%	58	64	70	76	82	88	94	100
4	55%	60%	65	70	75	80	85	90	95	100
5	64%	68%	72	76	80	84	88	92	96	100
6	73%	76%	79	82	85	88	91	94	97	100
7	82%	84%	86	88	90	92	94	96	98	100
8	91%	92%	93	94	95	96	97	98	99	100
9	100									100

As is very apparent only imports in the top left corner are likely to be healthy these days. In the past things may have been vastly different. If a given import is being sold cheaper than its tabulated value then an Importers Tax or FAIRPLAY TAX, should be levied by the government to bring it up to that value in order to see that that the Sunken costs are paid by those who aim to profit from the sale, not by other citizens³.

7 THE PROSPECTIVE EXPORTERS' POINT OF VIEW.

What about the X-trade from a prospective exporting nation Z's POV? Z might like to lure away the wages and the profits of the X-industry, but would have to bear the Transaction (exporting) costs of the trade and pay off the investment (T_0 years) it would have to lay out to start the industry up in Z. Using an identical argument to the one we used earlier, we find that the Prospective Export Test (PET) an entrepreneur in Z

³ If the imported item is sold F times cheaper than the home-made item, instead of

f_x times, then the Fairplay tax upon it should be $\left[1 - \frac{1-f_x}{F}\right]$ times the retail price.

will need to apply before investing in a local X industry to make exports would be, if he wants to profit from it :

$$\frac{2T_0}{T_D} < (1 - E_x) \quad (6)$$

where the only new factor is E_x , the fraction of his annual Value-Added which would go into exporting the commodity X (his Transaction cost, transport abroad for instance). [E_x must be less than 1 otherwise he would get no receipts, and note that his T_0 and T_D are not *necessarily* identical to the prospective importer's values.]

The noteworthy feature of the PET is that as the transaction costs E_x fall, so more, and more sophisticated, trades will appear attractive to prospective exporters. For the case when $E_x = 0.9$, T_0 / T_D would have to be $< 1/20$ or 5% to make a profit: i.e. export jute sacks but not coal. But as E_x falls to virtually zero (a container ship can bring a 20-ton container to Europe from Asia for less than a thousand dollars) so industries with start-up costs T_0 / T_D as high as 0.5 (e.g. cars) could generate a profit. So as time goes by prospective importers will be tempted with more, and more sophisticated, cheap trades from abroad – which will eventually ruin them, if they ignore the Sunken Costs.

It is interesting to ask what a prospective exporting government could do to encourage its entrepreneurs to take up more sophisticated export trades which otherwise would not surmount the PET barrier. The obvious thing would be to offer the entrepreneurs the equivalent of, say 2, years of Value Added towards their start-up costs (T_0). The LHS of (6) would then fall to:

$$\frac{2(T_0 - 2)}{T_D} < 1 - E_x$$

enabling more sophisticated (higher T_0) trades to take off. But there is no point in doing that (from the POV of the exporting nation *as a whole*) unless their government can recoup their loans to the entrepreneurs out of taxes on the newly imported

profits and wages. It then turns out that, without losing out, the exporting government can only help its entrepreneurs at the margins. In other words ‘aggressive exporting nations’, if there be such, can only dump cheap goods abroad by ultimately harming themselves.

So the conclusion of this section is clear: it is almost entirely up to a prospective importing nation to determine whether the Sunken Costs of importing cheap X’s are worth the candle; only its government can do that. There will always be importers, and their spokesmen, who claim otherwise, hoping to make large profits by dumping those Sunken Costs on others.

8 SOME GENERAL IMPLICATIONS.

There are winners and losers in Free Trade: big time winners like multi-nationals and high street vendors who import cheap foreign goods, sell them on to the populace at a high mark-up, then scuttle off abroad without paying the Sunken Costs; small time winners like you and I who get our goods a little cheaper; and big time losers, principally domestic industries driven into closing down, with their investments scrapped, their profits forgone, and their employees deprived of their livelihoods. From whose point of view should one sum up the balance of profit and loss?

It seems obvious to me that the balance should be made over the community as a whole, where the community in this instance is the political unit with the power to take decisions and enforce them by law. With exceptions this will be the nation-state today. And that makes sense because only the state can recompense the losers and tax the winners so that overall fairness and equity could in some measure be ensured.

The FTT has been devised so that any nation can find out whether a potential import will benefit its citizens as a whole, *including the Submerged Costs*. Will the immediate savings at the point of retail sale exceed the more remote costs at the domestic source of production? It is an obvious calculation to make, but apparently it hasn’t been made so far, or if so not

properly. Perhaps it looked too forbidding when phrased in monetary terms. The surprise is that if one works in human terms, in years of a life lived, so many superficialities (like exchange rates) cancel out leaving a test:

$$f_x T > T_0 + 0.1T + \left(0.9 - \frac{T_0}{T_D}\right) \times T_w \quad (7)$$

which most of us could do in our heads. And that, from a democratic point of view, is fundamental; we will no longer be left at the mercy of ‘experts’ whose expertise cannot be guaranteed and whose disinterestedness should not be assumed.

The outcome of the test is that FT in general is, from the importers point of view, neither good nor bad. The test has to be applied commodity by commodity, community by community, epoch by epoch. That truth should have been obvious from the start but it seems to have evaded whole church-congregations of vocal economists who have treated FT as if it were a crusade, not a matter for rational consideration. Yes it makes sense for Britain to import Asian spices, but not apparently German cars or Polish coal. It is as simple, and yet as complex as that.

Yes the test has to be re-applied epoch by epoch, even decade by decade! Why? Because over the years the factors within it may alter, either absolutely, or relative to one another, and when they do the outcome will probably change too. For instance as a nation’s industries become more sophisticated so their T_0 s will rise (become more capital intensive) and as its employees become more skilled and come to have higher expectations of life so their T_w s, at least in a civilized state, will rise too. And here is the vital point: both rises require concomitant rises in $f_x T$, the hurdle which every beneficial import must overcome. However the really decisive factor is the Turnover (or Churn) Time T. Over the last two centuries the world had dramatically speeded up, and T has fallen as low as 10 years today. But f_x and T are coupled together on the

interrogative (left-hand) side of the test as $f_x T$. Thus if T falls so f_x must rise to compensate. If T halves so f_x must double – changing the entire balance of benefit and loss for the import X in question, and indeed for all imports because T is not X -specific, it is a property of the commercial world at large. Whereas Britain might have benefitted from importing Volkswagens in 1960, in 2017 they could be positively poisonous to the British organism as a whole. When did you hear economists or politicians admitting that?

We have come to the crux of the matter. The whole trend of history is towards shorter T 's, higher T_0 s and longer T_w s, every such trend increasing the height of the hurdle f_x which import X must overleap if a society as a whole is not to lose. Imports which may have made sense in the past could well be poisonous today because of increasing Submerged Costs in the form of domestic industries that will be scrapped, and dis-employed employees who will need government support. Indeed those Submerged Costs may well have been too high a generation ago – but we just didn't look under the surface; some of us deliberately.

As we hinted earlier it rarely pays for nations at equivalent stages of development (equivalent T_0 s and T_w s) to import from one another commodities which both could easily make themselves. Where there are unique natural advantages, or unique native skills, trades will still make sense. Where there are none, what is the point?

That is a good question with several possible answers. One is to reap the benefits while hoping to dump the Sunken Costs on other nations; another is for parasitical importers to trouser the gains while leaving their fellow citizens to pick up the Sunken Costs. And some employments are more desirable than others. Thus a country might choose to give up coal-mining in favour of making aeroplanes – which is healthier. But then who is going to mine the coal – in any nation at an equivalent state of development? And it might be a trifle expensive to re-train 50 year old miners to become aeronautical engineers.

So most of the trade within a reasonably homogeneous block such as the European Community must be generally destructive to its inhabitants as a whole. Washing-machine manufacture in Britain is switched to Italy leaving the Sunken Costs of the move behind. Then from Italy to Poland with the same motivation – and so on and so on. In that mindless churn infrastructure is wasted and lives are ruined in a game of pass-the parcel which, so far as I can see, could be won only by parasites, including tax-avoiding multi-nationals. We urgently need to put on a Fairplay Tax to stop them running off with our childrens' lives.

9 RETRODICTIONS, RECOMMENDATIONS AND PREDICTIONS.

Retrodictions:

- Low productivity, low average wages and low quality jobs followed from heedless churn.
- Complementary industrial growth exploded in less developed countries such as China for the same reason. Many western industries which should have been protected, were allowed to leak away through the neglect of Sunken Costs.
- Decent jobs for young people disappeared in Europe and America leading to much otherwise unnecessary immigration and emigration.
- Tax-evading parasites and multinationals made vast fortunes at our expense. And bought influence with their ill gotten gains.
- Megacities like London exploded mainly because the relocation costs of Churn would be locally less within them. By contrast provincial areas of specialized skills, once the centres of national prosperity and pride, withered away because they bore the burden of disregarded Sunken Costs (Glasgow, Birmingham, Leeds , Swansea, Sheffield, Detroit, Pittsburgh, Lille, Manchester.....)

- Insecurity, unhappiness and lack-of self confidence grew in advanced economies everywhere.
- Political unrest, widespread political unrest capable of displacing experts and replacing governments, became inevitable.

Recommendations:

- We all check out the Free Trade Test, *and if we believe it*, act accordingly.
- We set realistic values for T_w because, apart from funeral directors, sooner or later nearly all of us are going to be churned.
- We stop importing commodities which, because of their Sunken Costs, are far too dear. From a British, indeed European POV, cars, computers, white goods, electronicscome to mind. If that means tariffs or quotas, so be it. Tariffs, or as they should be properly called ‘Importers’ or ‘Fairplay Taxes’, are just one way to recognize and compensate for Sunken Costs. The case for Free Trade has to made country by country, time by time, commodity by commodity, over and over again.
- The European Community is itself free to apply the FTT to imports from outside its community borders. It should do so to protect its own citizens. By pursuing internal FT instead Brussels has been cutting its own throat, or rather the throats of young people in Greece, Italy, Spain.....
- Ignore lobbyists and think-tanks because most are paid to lie on behalf of vested interests aiming to defraud the rest of us. Find out exactly where their money comes from before listening to a word.
- Dismiss all arguments phrased in financial jargon. Even if they are right, which is unlikely, they dangerously undermine the whole democratic process. It is largely a way for a priesthood to get away with grand larceny. Ever heard of the Sale of Indulgences? Transparency ! Transparency! Transparency! Nail that to the modern church door.

- Cease believing that big time computer geeks are geniuses. Most were or are simply monopolists who are manipulating the completely broken American patent system. What on Earth did Bill Gates do to pocket 70 billion dollars? If America won't put that system in order, and right away, then we should ignore their patents. They didn't invent computers. It's like anti-biotics all over again: discovered in Britain but patented in the USA. Come on governments; wake up!
- We should re-establish some selected industries that were wrongly allowed to leak abroad, using tariff barriers if necessary. But quickly before the local skills have been entirely lost.

Predictions:

- If most of such recommendations are ignored then the symptoms of disease alluded to under Retrodictions can only worsen, most especially political alienation and unrest. Hitler was voted into to power for economic reasons! Railing at Trump or Brexiteers is sticking one's head in the sand.
- Provided its negotiators care to understand the FTT and the PET and impose appropriate Fairplay Taxes, Britain will thrive following Brexit.
- The European Community will gradually break up unless it returns to its roots as a political, not an economic confederation, and unless it applies the FTT to its external trade. It was set up to try and prevent another frightful war between France and Germany; trade was a subsidiary consideration. We must all wish the EC countries good luck in coming to their senses!
- Some traditional, and some new industries will grow and thrive behind protective Fairplay Taxes. Multi-nationals, and their economist apologists, will scream blue murder.

- Our children and grandchildren will have better jobs and prospects than we have.
- The West as a whole will regain its self-confidence, and its ability to invest in the future, which will benefit all humanity in the end. Scientific invention and discovery, which are the ultimate sources of most new wealth, cannot be taken for granted. The climate has to be right.

10 THE HISTORICAL EVIDENCE

If Free Trade were the magic bullet it has been hailed as then surely there would be strong evidence for it in the historical record. But if you follow up the historical record⁴ in fact the opposite seems to be the case. Subsequently powerful industries so often mushroomed behind strong protective barriers or because of direct government support: for instance British shipping (the Navigation Act of 1650); steam powered industry in the same country (James Watt's patent on his steam-engine with separate condenser lasted for 75 years in all); Japanese car manufacture (a huge tariff was imposed on foreign cars after 1936); the American commercial airliner industry (the USAF funded the development of the Boeing 747 as a potential military transport, but chose the Lockheed C5 instead); the Silicon Valley computer industry was largely based on government funded military research (the Transistor, and then SAGE which got IBM into the business) and is now shielded behind stifling and unhealthy patents. They even tried to patent the curve on the I-phone corner.

The classical case for FT was written by David Riccardo (1817) who used as his example trade between Britain exporting manufactured clothing and Portugal exporting wine. In fact the FT imposed on Portugal turned out to be an absolute economic disaster for that country which missed out on the industrial revolution and was left growing wine. And Britain embraced FT in 1845 when it abandoned the Corn Laws. Between 1815 and

⁴ As usual Wikipedia is the best place to start; there is an excellent review "The Free Trade Debate"

1914 its per capita GDP dropped from being twice that of any other country to being twelfth in the world. That may be a coincidence of course.

The whole situation was summed up by a historian of Economics as follows⁵: “The fact remains that history’s strongest advocates for Free Trade – Victorian Britain, post WWII United States, were strongly protectionist during their own growing stages.”

N.B. It is important to recognize that *all* job losses, particularly in manufacturing, *cannot be blamed on imports*. As we saw in section 4 productivity in the manufacturing sector has risen by 500% over the past 60 years, mainly as a result of improved technology and increased investment. Thus it takes less jobs to produce the same amount of manufactured goods, and so even without cheap imports a significant number of manufacturing jobs *could* have been lost anyway – but don’t forget that our consumption of those same goods was also rising dramatically – think cars for instance. Thus it is not simple to assign the main causative agent of job losses to one thing or the other; in Section 4 we estimated that roughly 3 out of 4 are due to imports. But that difficulty is not relevant here because all we are doing is trying to make sure that cheap imports themselves do not cause more harm than good to the importing nation. If they do lessen the market for home-made goods then they *will* cause losses of jobs and investment which *someone* will have to pay for. And that is the point. Yes there may be other reasons why jobs are being lost in say horse-shoe making, and they may be significant, but that has nothing to do with the issue of FT, either way.

11 COULD ALL THIS BE WRONG?

Of course it could – that is why we should all check it out for ourselves, particularly Section 2 in which the FTT emerges.

⁵ David Landes “The Wealth and Poverty of Nations”, 1998, Little Brown, UK, p 266.

The author is not an economist, not a financier, nor even an accountant, but an astrophysicist with an inexplicable 60-year-long fascination with macro-economics. His preoccupation with Free Trade was sparked by a 25 mile drive North from the prosperous city of Cardiff where he lives, to Merthyr-Tydfil, a hollowed out spoil heap which not so long ago produced 75% of the entire world's steel output. Why, one wondered, had its enterprising citizens, been so left behind. And was it inevitable?

Does this background, or rather lack of it, disqualify me from having something useful to say here? I would argue to the contrary as follows:

- Astrophysicists spend their working lives doing elaborate calculations of throughputs in complex natural systems like stars and galaxies. So Free Trade is right up their street.
- All the factors involved are quantitative. I have made no judgements as to human behaviour, leaving the reader to fill those in when choosing their value for T_w .
- In that sense this is little more than shop-keeper's accountancy with a twist.
- History shows that outsiders can break log jams by introducing ideas brought in from a different field. (thus Alfred Wegener the meteorologist who forced Earth scientists to confront Continental Drift). The imported idea here is the use of timescales (instead of monies) because that is what we use in Astrophysics. That simplifies and generalises the discussion enormously.
- Almost by definition we scientists have to be rather good at making mistakes, that is to say acknowledging them, altering our assumptions and then moving on. Thus our calculation here is the outcome of at least a dozen previous failures or if you like 'successive approximations' towards a sought-for truth. Other scholars may regard such

failures as a weakness. We scientists don't. On the contrary. It's how we find things out.

You could put the question another way and ask what other kind of expert could be expected to do a better job.

Not, I hasten to reply, any kind of academically trained economist. Aside from their lamentable record in predicting and curing crashes, their subject is undermined by *at least* two crippling philosophic handicaps⁶:

- Economists cannot use Induction (arguing from the particular towards the general) because Economics defies the Principle of Limited Variety: there are too many hypotheses out there for any feasible evidence to make convincing selections of the likeliest. And Induction has to be the foundation of any science. So Economics is not, and can never become a science, not even a 'dismal' one. So much for their 'Not the Nobel Prizes'.
- Economics is 'Reflexive' or self-defying. For instance if a credible economic theory predicted that farmers would do better selling beef than milk, smart farmers would get out of dairying, thus putting up the prices and profits from milk, while other equally smart farmers would be producing so much new beef as to drive their own profits down.

If you ask me, after delving into the subject for 60 years, Economics is, like Psychoanalysis, sorcery dressed up to seem like science; but a very nice earner nonetheless (sincerity is no defence, on the contrary). If you don't believe me go on the web and find out what they teach on the PPE course at Oxford, or at Harvard in their MBA⁷, two mills through which so many

⁶ See for example "The End of Theory" by Richard Burkstaber, 2017, Princeton University Press.

⁷ Or read "What They Teach you at Harvard Business School" by Philip Delves-Broughton.

Masters of our Universe nowadays pass. You might laugh first – but then cry.

Let us finish here with three Quotes:

From J. K Galbraith, Economic Historian, Harvard , 1960's:

“Economics was devised to make Astrology look respectable.”

From Milton Friedman, *Capitalism and Freedom*, 1962, University of Chicago Press, p 4. Friedman was ‘The Economist of the Century’ according to Fortune magazine, and a winner of the ‘Sort-of-Nobel-Prize-in-Economics’. Reagan and Thatcher claimed to be disciples:

“...the great advances of civilization, in industry or agriculture, have never come from centralized government.”

Friedman's statement is utter nonsense; as factually wrong as stating ‘The Earth is flat.’ [Think only of: sewerage systems, clean water, computers, space-satellites, anti-biotics, jet engines, radar, the internet, broadcasting, machine-tools, anti-scorbutics, satellite navigation, astro-navigation, mass productionon and on and on.] To believe such twaddle Friedman has to have been either a fool, or a zealot – which is much the same thing, or in the pay of sinister forces. Or maybe just an economist.

A.E. Houseman, the poet, in his inaugural lecture as Professor of Classics at University College London in 1892:

“This method, conclusion first, reasons afterwards, has always been in high favour with the human race: you write down at the outset the answer to the sum; then you proceed to fabricate, not for use but for exhibition to the public, the ciphering by

which you can pretend to have arrived at it. The method has one obvious advantage – that you are quite sure of reaching the conclusion you want to reach. If you began with your reasons there is no telling where they might lead you, and like enough you would never get to the desired conclusion at all.”

12 THE BURDEN OF PROOF

Throughout history reactionary forces have retained power by saddling their opponents with ‘The burden of proof’. So it is here. ‘Free Trade is,’ they assert ‘ so obviously a good thing that you stick-in-the-muds have to prove otherwise’. But this is nonsense; the case for Free Trade has to be made, just as has the case against. This isn’t, or shouldn’t be a religious question but a technical one that has to be debated over and over again, commodity by commodity, as circumstances change. The original case for FT was made first in the 18th century by Adam Smith, who was against monopolies: “ The interest of manufacturers and merchants is always in some respects different from, and even opposite to, that of the public. The introduction of any new law or regulation of commerce which comes from this order always ought to be listened to with great precaution, and ought never be adopted till after having been long and carefully examined, not only with the most scrupulous, but with the most suspect attention.” Hear hear. This is what we attempt here. There are 30,000 professional lobbyists in both Brussels and Washington, many paid by multinationals!

Alas Protectionism can be and has been abused, which is why each case must be examined on its merits. Thus the Corn Laws were imposed (1815) in Britain to enrich the landowning classes and the Church (the largest landowner) at the expense of the working class who desperately needed, and could have had, much cheaper imported food]. So the battle lines were drawn and Free Traders came to see themselves as progressive – as indeed they were in this particular 19th century instance. But for goodness sake the

world has changed since then, over and over again (not least because of FT itself). No one today has the right to place the burden of proof on any other shoulders but their own.

Anyone who tries must be suspected of having too weak a case to expose it to open scrutiny.

If only for the sake of our own children's livelihoods we all need to understand the implications of FT, and of globalization more generally. God didn't invent it; we did. Or our grandfathers' grandfathers did.

13 THE POLITICAL DIVIDE.

There are those who will maintain that an individual's working life is his own affair, that if he doesn't like what he's got he should up sticks and go find another job elsewhere. Their opponents will argue the contrary: that it is a central task of any society to provide, if they can, stable working livelihoods for most of their citizens most of the time.

The FT issue plays out in the tension between these two extreme points of view, and it has done for several hundred years. What has changed is the ever accelerating speed-up of commercial life. Should we welcome it, or try to mitigate it? If the latter then the FT issue has to become absolutely central to political debate.

Personally I think it is too much to ask that any family be involuntarily uprooted from familiar backgrounds, working or social, more than once in their lives, so that they can get 10% cheaper washing machines. If societies are to earn the loyalty of their citizens in times of stress or war, then it must give them stability back. What more important task does government have – than provide stability? In an era of speed-up that will be increasingly hard – but by no means impossible – if voters care enough. Speed-up is not a profound, irresistible force of Nature, it is a man made, unintended consequence, rather like pollution. Why should our lives be first threatened, then ruined by it? It makes no sense – not even in narrow economic terms.

14 IN CONCLUSION

It feels to me as if we are all entangled in a ghastly but unnecessary struggle – not unlike the First World War. Only after it was over (1921) did an atmospheric physicist, Lewis Fry Richardson, point out that it had probably originated in failure to recognize a mathematical truth; namely that while arms races can potentially prevent wars, they can only do so if both sides can disarm faster than they can arm. Alas this was not true in 1914 and, as Richardson retrodicted, that would have led to Armageddon. Following the 1962 Cuban Missile crisis, which terrified all the commanders involved, a hot-line was established between Washington and Moscow to ensure that Richardson's imbalance thereafter prevailed. That we are all still here may be owed to that simple, but felicitous, calculation. So check whether

$$f_x(\%) > 10T_0 + 10 + (9 - T_0) \times T_w$$

makes sense to you. It could save your working life, or the working lives of your children.

Free Trade, or Globalization as it is called nowadays, is churning all our lives, from Timperly to Timbuctoo. The economic fault-lines have completely changed since this debate began. Shouldn't the political ones evolve too? If they don't, revolution could replace evolution, as it has done in the past, often with tragic consequences.

GLOSSARY

f_x fraction by which an import X must be cheaper than its domestic equivalent if importing it is to do no overall harm to the importing nation.

T Turnover- or Churn-Time of the commercial world. Time over which reliable commercial prediction can be made.

T_0 Investment accumulated in the domestic X-industry, in years of equivalent Value Added.

T_D The Discount time, over which invested loans must be paid back.

T_w The number of years of income equivalent it will cost to get a disemployed employee (with their family) back to their feet.

V_{pa} The annual Value-added by the domestic industry (X) in question.

I_0 The start up investment cost in industry X

$$\frac{V_{pa}}{V_{pa}} = \frac{I_0}{T_w} \frac{I_w}{I_w}$$