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Reassessing Ireland's Economic Development through the Lens of Sustainable Development

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Reassessing Ireland's Economic Development through the Lens of Sustainable Development

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Abstract
Economic historians have examined economic development in terms of growth for decades. However, only limited research has examined historical economic development from the vantage of sustainable development. Genuine Savings (GS) has emerged as a leading economic indicator of sustainable development. This study reassesses Ireland's economic development by analysing GS estimates that span the entire history of the Irish Free State from 1922-2017 as well as notional estimates back to 1851, just after Ireland's "Great Famine". The findings provide empirical support for the view that Ireland's economic performance was held back by an archaic institutional framework that prevented a convergence to modern living standards during the European Golden Age. The results amplify the sharp contrast between pre-1960s and post-1960s economic performance noted in the traditional literature on Ireland's economic history. The study shows that Ireland might be viewed as "a land of missed opportunities" before it underwent a "great transition" driven by an improved institutional framework. Ireland's great transition paved the way for the sharp relative welfare improvement during the Celtic Tiger period of the 1990s. Ireland offers novelty in relation to the GS literature having undergone two distinct development phases before economic convergence. The first phase from 1960-80 represented a typical weakly sustainable path. The second phase from 1987-2007 represented an Environmental Kuznets Curve type path.

Key words: Green accounting; Genuine Savings; Natural capital; Convergence; Environmental accounting; Sustainable development; Ireland

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Introduction

Economic historians have examined development in terms of growth/output for decades. However, only limited research has examined historical economic development through the lens of sustainable development.[1] The economics of sustainable development stem from the crucial link between inter-generational human welfare and the productive capacity of an economy. Productive capacity depends on the available stocks of capital resources and technological growth, together referred to as "comprehensive" wealth. Wealth is comprehensive in the sense that it includes all welfare relevant assets. Capital must be broadly defined beyond conventional physical capital and include assets such as the natural environment, social/institutional capital and human capital. Changes in comprehensive wealth, the assets that provide current and future consumption flows, must affect future welfare. Genuine Savings (GS) are the net investments in the broadly defined capital assets and represent changes in productive capacity or comprehensive wealth. Arrow et al., (2012) show that if GS at time t is positive and evaluated using the correct shadow prices then inter-generational well-being is rising. If GS is persistently negative, then future well-being must fall and thus development is termed unsustainable.[2]

Economists broadly agree that sustainable development entails some form of capital or wealth maintenance but the debate surrounding the precise conditions continues. The literature generally considers GS as an indicator of "weak" sustainability. Under the weak sustainability paradigm, the maintenance of total aggregate wealth is key with no constraint for individual capital stocks. To achieve weak sustainability one or more of the following must hold; natural resources are superabundant, sufficient substitution possibilities exist between natural and physical capital and/or technological advancement makes substitution possibilities a moot point (Neumayer, 2013). Proponents of "strong" sustainability largely reject substitution possibilities between natural and physical capital and instead argue for

[1] Long run studies of sustainable economic development have been undertaken for Germany, USA and UK (Hanley et al., 2016), Australia (Greasley et al., 2017), New Zealand (Qasim et al., 2020), Sweden (Lindmark and Acar, 2013) and Latin America (Blum et al., 2017).

[2] The World Bank has operationalised the economic theory to provide GS estimates for most countries from 1990 and as far back as 1970 for some (World Bank 2006; 2012; 2018). The development from theory to practical estimation is the result of decades of research examining the appropriate adjustments to conventional national accounting aggregates required for sustainability measurement (Pearce and Atkinson, 1993; Hamilton and Atkinson, 1996; Hamilton and Clemens, 1999; Weitzman, 1997).

non-declining natural capital as an additional stronger constraint (Costanza et al., 1991).

GS is now a well-developed concept in theory and practice yet little is known about the long-run dynamics of GS for modern economies and how those dynamics are related to the phenomenon of economic convergence. In this paper, the first examination of the entire development path of a modern well-developed economy is presented. Estimates that span the history of the Irish Free State from 1922-2017 are constructed as well as notional estimates back to 1851, just after Ireland's "Great Famine". Ireland's economy has been of interest to economic historians for several reasons. Firstly, the country moved from an inward looking agricultural focused economy to an outward-orientated, industry focused one following the much-lauded Economic Recovery Plan of the 1950s (Nolan et al., 2000). Secondly, the country saw rapid economic convergence within a decade during an economic expansion known as the Celtic Tiger from 1987-2005 following a long period of severe underperformance.

The construction of long-run Irish GS offers an opportunity to reassess the traditional view of Ireland's economic development from the vantage of sustainable development. Examining Ireland is particularly important given much of the historical GS literature has focused on the countries that were already well-developed by the mid-to late 19th century rather than those that converged during the 20th century. The traditional view of Ireland begins from a recognition that many western European economies experienced economic convergence during the European Golden Age from 1950-73 with poorer countries growing much more rapidly than richer ones (for a review of the Golden Age, see Temin, 1997 & 2002). Ireland was a severe underperformer and in the context of the European Golden Age was viewed as a spectacular economic failure. Ireland's Celtic Tiger then emerged after its institutional framework had been modernised and resulted in rapid convergence within a decade. Convergence was viewed as a delayed version of the Western European growth miracle (Ó Gráda and O'Rourke, 1996; Honohan and Walsh, 2002).

Tentative findings from the limited literature suggests negative GS rates, a signal of unsustainable development, for modern developed economies were likely to have been rare and confined to periods of major economic shocks, such as the World

Wars (Blum et al, 2017). Lindmark and Acar (2013) studied Swedish GS from 1850-2000 and posited that a "great transition of Swedish sustainable development" occurred during a period of large and sustained GS rates from 1930 that set the foundations for Sweden's convergence during the European Golden Age. Lindmark and Acar (2013) suggested that contemporary developed economies each underwent their own great transition that coincided with or preceded convergence and saw an important task for future researchers "to validate or disprove the existence of the great transition as a general phenomenon". Little is known of the development paths followed by the economies that converged other than Sweden during the mid to late twentieth century thus studying Ireland's historical GS allows a further examination of the great transition hypothesis.

The key aims of this paper are to (1) Present the first long-run historical analysis of GS for Ireland covering the period 1851–2017. Three previous studies have examined Irish GS over much shorter periods. Ferreira and Moro (2013) from 1995-2005 and McGrath et al., (2019) & (2020) from 1990-2016. The lack of detailed historical macroeconomic accounts for Ireland (Gerlach and Stuart, 2015) makes it a challenge to construct long-run GS estimates but this study demonstrates that even where there are sparse national accounts one can estimate GS over the long run. (2) Reassess Ireland's economic development through the lens of sustainable development and examine the great transition hypothesis posited by Lindmark and Acar (2013). The savings estimates for post-independent Ireland are discussed within the context of six key periods. The contrast between an economic assessment based on growth and sustainable development is discussed for each period. An examination of comparative economic history in terms of GS is also undertaken. (3) Enhance GS estimation by adding relevant assets for Ireland such as peat depletion, forestry growth, changes in agricultural land value, and local air pollution that are typically omitted by the literature. The inclusion of peat depletion and agricultural land value (as returns from the produce of land) are innovations in the historical analysis of GS. (4) Incorporate the present value of future technological change, a key factor for enhancing the predictive power of GS (Weitzman 1997; Greasley et al., 2014; Mota and Cunha-e-Sá, 2019). The addition of technical change is important as the World Bank and Ferreria and Moro (2013) omit these estimates altogether. McGrath et al. (2019) provide estimates that cover 1990-95, but these estimates are based on

averages from the literature rather than from a growth accounting exercise. (5) Augment the measure of technical change to account for the changes in natural capital included within the GS model. GS studies have generally included technical change by estimating the "Solow residual" or total factor productivity (TFP) from a standard growth accounting exercise. Standard growth accounting leads to an inconsistency problem as it ignores the natural capital included within the GS model.

The remainder of the paper is as follows; section 2 presents the theoretical framework of the GS model. Section 3 details the construction of the GS estimates for Ireland. Section 4 next presents the results of Ireland's GS from 1922-2017 and 1851-1922. In section 5, Irish GS within the context of comparative economic history is discussed, Ireland's economic development is re-assessed and the great transition hypothesis is examined. Concluding remarks are provided in section 6.

Theoretical Framework

The theoretical model used to understand how to measure welfare changes and to indicate weak sustainability is a generalised model of economic growth. Weitzman (2017) solidified the model within what he termed the "pure theory of perfectly complete national income accounting". This general comprehensive or "green" accounting model considers an economy with a constant population where utility at time *t*, $U(C(t))$ depends on a consumption bundle that includes all the determinants of instantaneous utility, $C(t)$.[3] Production depends on a vector of capital stocks inclusive of all determinants of net productive capacity, $K^*(t)$. Changes in these stocks of capital are represented by net investments, $I^+ = \dot{K}^+$. The superscript + indicates the "augmentation" of the assets to allow exogenous technical progress to be included by following Pemberton and Ulph (2001) and Pezzey (2004) where time can be considered as a form of capital, i.e., $K^+ = (K, t)$ and $I^+ = (I, 1)$. Production possibilities are a convex set S that depends on K^+ so that (C, I^+) is feasible given K^+, if and only if $(C, I^+) \in S(K^+)$. A resource allocation mechanism (RAM) exists that characterises all the constraints faced by the given economy. The constraints cover all real-world distortions be they technical, institutional or

[3] For a growing population, Hamilton & Atkinson (2006) recommend dividing GS by total population, deducting a Malthusian correction term that multiplies wealth per capita by the population growth rate.

environmental and co-evolve with the economy over time to form the superstructure for resource allocation decisions. As Dasgupta (2009) notes, the RAM need not, in theory, be efficient or include a benevolent social planner. The RAM will define the path for $C(t)$, $I^{+}(t)$,$K^{+}(t)$ that may or may not be optimal. In this context, Asheim (2007) shows that the present value of future consumption changes equals the value of net investments, i.e., Using a constant real interest rate, R;

$$PV\Delta C = \int_{t}^{\infty} (P_C(s)\dot{C}(s))e^{-R(s-t)}ds = P_I(t)I^{+}(t)$$

Where P_C and P_I represent the shadow prices of consumption and investment, respectively.[4] The powerful conclusion of the general model is therefore that the level of "correctly" valued GS ($P_I(t)I^{+}(t)$) corresponds to variations in intergenerational well-being. Welfare (e.g., the present value of utility flows) is unobservable, but under general conditions, the PV of future changes in measured consumption can signal welfare changes. Two main definitions of sustainable development dominate the literature. One postulates that development at a particular moment is sustainable if the maintenance of current consumption forever is possible (Pezzey, 2004). The other assumes that development is sustainable if welfare is not decreasing through time (e.g. Arrow et al., 2012). In both cases, if GS is persistently negative, development is not sustainable. However, having positive GS implies at least an initial welfare improvement (Arrow et al., 2012) but does not guarantee that consumption will not decrease at some point in the future (Asheim, 1994; Pezzey, 2004), and in this sense, GS represents an indicator of unsustainable development.

Methodology

The theory outlined above is demanding and requires a complete accounting of all components of net productive capacity and each evaluated at the correct shadow prices. In practice, the components placed within K and how those components are valued will be constrained by data availability. The empirical literature generally posits $K = (K_f, K_h, K_n)$. Capital consists of physical (K_f), human (K_h) and natural

[4] For the properties of the Divisia consumer price index to translate market values into shadow prices see Asheim (2007).

capital (K_n) assets. Pearce and Atkinson (1993) first presented the notion of a capital theoretic approach to sustainability measurement and provided the first empirical GS estimates. Hamilton and Clemens (1999) then provided a solid theoretical base and a technique to estimate GS from real-world data that serves as the foundation for the World Bank's GS indicator termed Adjusted Net Savings (ANS):

$$Adjusted\ Net\ Savings\ (GS) = GNS - D_f - D_n + A_h \qquad (3)$$

The World Bank calculates real-world GS by making "green" adjustments to Gross National Savings (GNS), a standard item reported within the conventional System of National Accounts (SNA). See World Bank (2018) for a detailed methodology. A deduction is made for the depreciation of physical capital (D_f) captured by the consumption of fixed capital (CFC) as reported within the SNA. Subtracting (D_f) from GNS equates Net National Savings (NNS) and signifies net physical capital investment. Net natural capital investments (D_n) are captured by the depletion of subsoil assets (oil, natural gas, and coal, bauxite, copper, gold, iron ore, lead, nickel, phosphate, silver, tin, and zinc), forestry depletion and pollution damages (carbon dioxide and particulate matter). The valuation of subsoil assets and forestry relies on a net present value approach that uses market prices and estimated costs of extraction. The valuation technique is unable to capture the non-marketed ecosystem services that may be large for assets such as forestry. The pollution damages are valued based on marginal damage cost estimates that reflect the present discounted value of expected future damages.[5] Finally, an estimate of human capital accumulation (A_h) roughly proxied by education expenditures is added. GS is then generally reported as a savings rate by dividing GS by Gross National Income (GNI).

An important omission from the World Bank methodology is an adjustment for technological progress. Many have argued for the inclusion of exogenous technical progress to be added as an additional stock, Q_t. If $Q_t = 0$, as assumed in the ANS model, the implication is that technical progress is fully accounted for in the stock changes captured in K i.e. "purely endogenous technical progress" (Pemberton

[5] The non GHG (particulate matter) is estimated as damages to country X from emissions in country X. For the GHG (CO_2) the polluter pays principle is employed where country X is notionally charged for its contribution to global damages.

and Ulph, 2001). Strong arguments have been made to "augment" the World Bank's GS estimates by including exogenous technical progress (Weitzman 1997, Pemberton and Ulph, 2001; Pezzey, 2004; Pezzey et al., 2006; Mota et al., 2010; Greasley et al., 2014; Hanley et al, 2015; Blum et al., 2017, Mota and Cunha-e-Sá, 2019). In general, GS studies have included exogenous technical progress by estimating the "Solow residual" or total factor productivity (TFP) from a standard growth accounting exercise. The common approach has been to estimate the net present value of trend TFP growth over time horizons of 10-50 years. By employing a standard growth accounting framework, one introduces an inconsistency problem where the GS model posits production is dependent on a more broadly defined set of assets than the physical capital and labour factors that are included in conventional growth accounting. When *K* includes human capital, as in the ANS model (Hamilton and Clemens, 1999) then for consistency the estimates of TFP growth should account for changes in the human capital stock. When *K* includes natural capital, a correction in TFP for natural capital should also be undertaken. As part of the historical analysis, two models of Irish GS are constructed.

Model 1: Genuine Savings (GS)

The first model is based on the World Bank ANS methodology where $GS = NNS - D_n + A_h$ with several important refinements. See Table 1 for a comparison between the World Bank ANS indicator and the GS estimates. In this study, only national data sources are used and the array of natural capital assets is expanded. In particular, the inclusion of pollution damages from sulphur oxides is important as sulphur emissions have been shown to be the most damaging pollutant for Ireland (Ferreira and Moro, 2013; McGrath et al., 2019). Another important addition is the inclusion of changes in agricultural land value, by far the largest component of Ireland's natural capital. Unlike the World Bank model, this study permits the appreciation of natural capital thus the adjustment for D_n may actually be positive in some years. For example, forestry growth in all years and changes in agricultural land value in many years is found to have been positive. The valuation techniques and data sources for D_n are discussed within the data appendix.

To calculate NNS the lack of consistent official historical national accounts for Ireland must first be dealt with. In doing so a "knitting" procedure is used to produce a consistent NNS series from the official but inconsistent data that is available back to 1938. The pre-1938 data relies on official historical estimates of Irish national income and unofficial estimates of GDP growth where changes in NNS are assumed to mirror changes in national income or GDP. More detail on the knitting procedure and data sources used to estimate NNS can be found in the data appendix. To calculate human capital accumulation public education expenditures from the CSO statistical abstracts are used where missing years are linearly interpolated. Public education spending is only available post-independence. Under the expenditure approach a strong assumption is made that every euro spent on public education yields exactly one euro in additional human capital. Consequently, many have criticised the expenditure method (Jorgenson and Fraumeni, 1992). Alternative approaches include the estimated rate of return on education, or an estimate of discounted lifetime earnings by skill level (Greasley et al, 2014). This study employs the expenditure method given the level of data demanded to undertake these alternative methods over such a long time period. In defence of the expenditure method, the World Bank argues that it corrects for the incorrect treatment of education spending as consumption rather than investment within the SNA (Hamilton and Clemens, 1999). The World Bank further argues that public spending on education can be interpreted as a lower bound estimate for human capital accumulation. An alternative view offered is that education spending may be an overestimate due to a lack of depreciation (Arrow et al., 2012) or the ineffectiveness of public schooling (Caplan, 2018).

In the Irish case another important issue is that of international migration. Much of the concern in the GS literature has been Malthusian in nature where the focus has been on the impact of a growing population on comprehensive wealth. In contrast, for much of Irish history the population has declined through emigration. The impact of emigration on GS should involve a reduction in the human capital stock to reflect a loss in available human capital but this will not be captured by annual education spending. To deal with this issue estimates of Ireland's GS excluding human capital are provided as part of a sensitivity analysis within the appendix (Figure A.1 and Figure A.2).

The GS estimates cover 1851-2017 but two distinct sets of GS estimates are considered; pre-independence (1851-1922) and post-independence (1922-2017). The pre-independence estimates do not contain human capital as public spending data is unavailable and the NNS data should be interpreted with caution given the lack of official data on national savings during this period.

Model 2: GS + the Present Value of Future Technological Progress (GSTFP).

The second model incorporates the present value of twenty years of future TFP growth (Q_t) thus $GSTFP = NNS - D_n + A_h + Q_t$. Given data constraints to estimate TFP growth and the 20-year truncation of Q_t, GSTFP covers only the post-independence period from 1923-97. To calculate Q_t the starting point is the conventional growth accounting framework with a Cobb-Douglas production function $Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$. Where Y_t is output (Gross National Income), A_t is TFP, K_t is physical capital input, L_t is labour input and $1-\alpha$ is labour's income share. More detail on the growth accounting exercise can be found in the data appendix. An annual TFP index is then constructed as $A_t = \frac{Y_t}{K_t^{\alpha} L_t^{1-\alpha}}$ where α takes the value of 0.3 based on Byrne and McQuinn (2015).

As discussed above, where the GS model includes an expanded coverage of capital assets than is contained within the conventional growth accounting exercise then an adjustment to reflect changes in those additional assets (human and natural capital) should be considered. The TFP estimates are adjusted to account for the natural capital inputs used in the GS model (agricultural land, fossil fuel energy, minerals, forestry and timber production) following Brandt et al., (2017) and Hamilton (2018). The expanded TFP estimates are denoted as TFP_N. Brandt et al., (2017) show that by assuming constant returns to scale in production and zero economic profits (other than the resource rents that are used to bring resources into the TFP measurement framework) the adjustment to standard TFP required in terms of growth rates to account for natural capital inputs is as follows $\frac{dlnTFP_N}{dt} = \frac{dlnTFP}{dt} + \sum_i \frac{{}^{u}S_i}{Y} \left(\frac{dlnK}{dt} - \frac{dlnS_i}{dt}\right)$, where S_i represents the natural capital asset i, Y is GNI and K is the physical capital stock. The implication is that if the quantity of physical capital is growing faster (slower) than the weighted average of the quantities of natural capital, where the weights are derived from the individual

factor shares, then adding natural capital to the analysis will increase (reduce) measured TFP relative to the standard metric and vice versa. The conventional TFP estimates are adjusted in this manner to obtain an annual TFP_N series. Trend TFP_N growth is extracted using a Kalman filter. To construct the monetary estimates of Q_t, the TFP_N share of output growth is calculated annually (based on trend growth) and the total is discounted over every 20 years at 2.6 percent based on Mota and Cunha-e-Sá, (2019). As part of a sensitivity analysis contained in the appendix, a Hodrick Prescott (HP) filter is employed to extract trend TFP growth.

Given the lack of data on both the level of educational attainment pre-1960 and the returns to different levels of education over such a long time-period, the TFP estimates are not adjusted to account for changes in human capital and thus may be introducing some double counting into the GSTFP model. To address this issue GSTFP estimates are presented where human capital is removed from the model as part of the sensitivity analysis. Mota and Cunha-e-Sá, (2019) suggest that making the adjustments for human capital changes within the TFP estimates has a negligible impact.

Table 1: Comparison of GS components: Current study and The World Bank

Component	*Current Study*	*World Bank*
Physical Capital	Net National Savings	Net National Savings
Natural Capital		
Minerals	Lead, Zinc, Silver, Copper, Gypsum, Barites	Lead, Zinc, Silver
Energy	Peat, Natural Gas, Coal	Natural Gas, Coal
Pollutants	Carbon Dioxide, Sulphur oxides	Carbon Dioxide, Particulate Matter
Renewables	Changes in Agricultural Land Value, Forestry Growth	N/A
Human Capital	Education Expenditures	Education Expenditures
Tech. Progress	PVTFP 20 year truncation (time series 1927-1997)	N/A

Results

The savings estimates for post-independent Ireland are discussed within the context of six key periods dated based on the traditional growth based literature on Ireland's economic history. In each case the GS estimates are first presented followed by a discussion of the political background of the day, the economic policies being pursued during the period and economic performance in output terms. An assessment of economic performance based on economic growth is contrasted with an assessment based on sustainable development for each period. Figure 1 and Figure 2 present GS and GSTFP per capita in constant 2000 prices and savings rates as a percentage of GNI from 1922-2017**.** Table 2 illustrates the breakdown of the savings estimates from 1922-2017 as a % of GNI. Notional estimates of Irish savings pre-independence from 1851-1922 are presented at the end of the results section as they are not directly comparable with the post-independence estimates, as discussed in section 3.

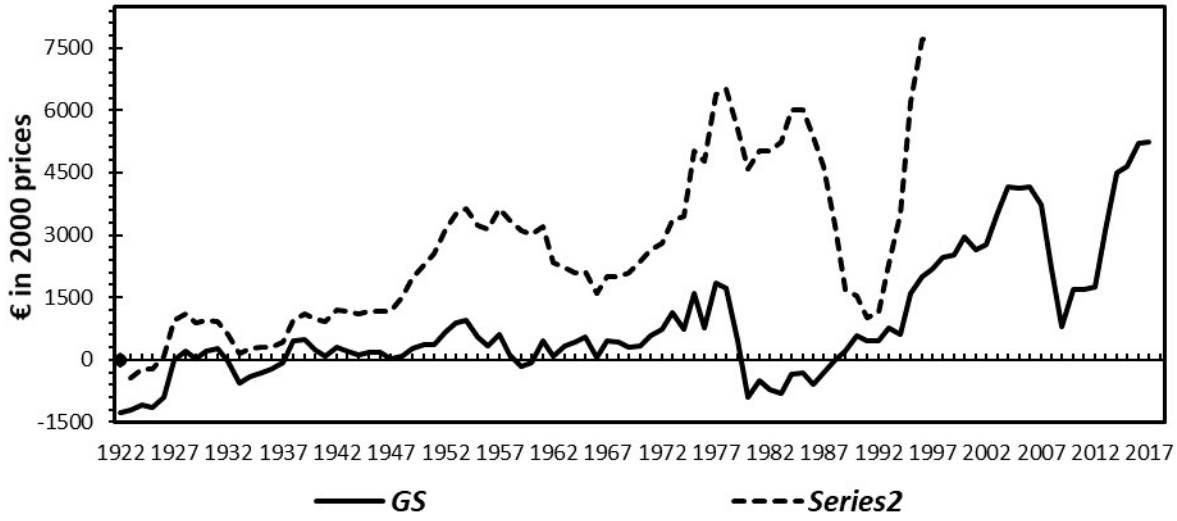

Figure 1: GS and GSTFP per capita 1922-2017 (in 2000 prices)

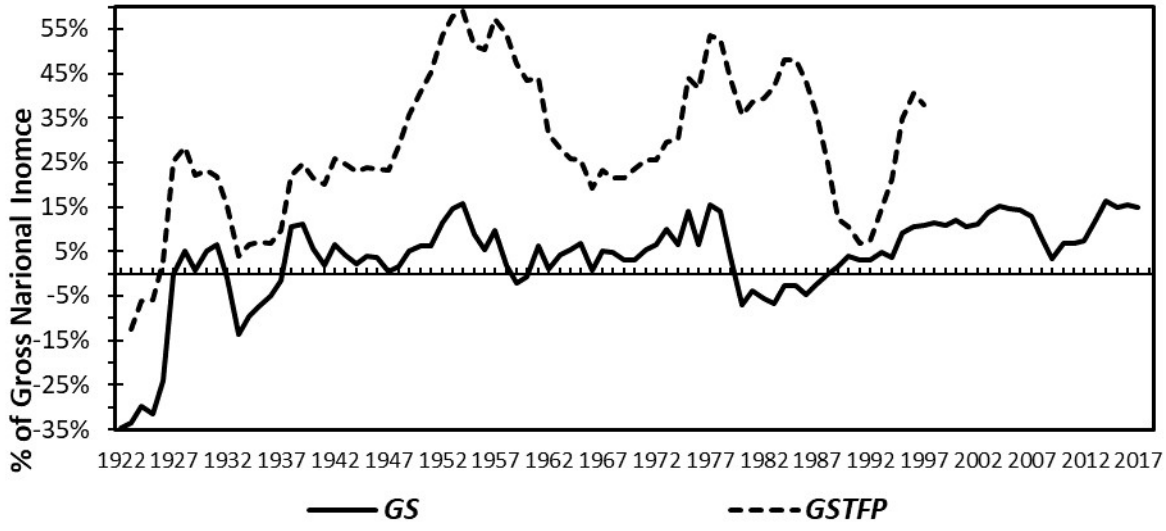

Figure 2: GS and GSTFP as a % of GNI 1922-2017

Independence to the Economic War 1922-1932

It appears that Ireland recorded negative GS from 1922-28 and negative GSTFP from 1922-26 indicating a period of unsustainable economic development (Figure 1 and Figure 2). Positive and rising savings rates then emerged in tandem with steady conventional growth during the remainder of the period. Savings rates reached 6-22 percent of GNI by 1931. GS and GSTFP per capita stood at €300-€3,000 (in 2000 prices), a considerable increase from respective lows of -€4,000 and -€1,400 in 1922. Changes in agricultural land value largely determined GS rates (Table 1). The magnitudes of the negative adjustments for land value were larger than that of PVTFP

during the first five years of independence. The inclusion of changes in land value may seem a strange sort of "investment" given the common usage of the term. The focus on broader capital assets also requires a broader view of investment. As Arrow et al., (2013) explain, comprehensive investment should reflect, *"any increase in the flow of services that the asset can provide over its lifetime"*. It is in this broader sense that changes in land value constitute investment. Pollution damages wiped out the combined positive contribution from net physical capital investment and education expenditure while other natural capital depletion was negligible.[6] Sulphur emissions drove total pollution damages, in turn, driven almost entirely by the combustion of solid fuels (Mylona, 1993). Sulphur emissions rose from 1 kilo-tonne (kt) in 1922 to 80kt by 1931.

The Anglo-Irish treaty 1921 established the Irish Free State as a self-governing dominion of the British Empire. The treaty was so divisive it split the nationalist movement and passed by only a slim-majority in the Irish parliament. The pro-treaty contingent won the 1922 general election but tension was so high that a civil war broke out and lasted for over a year. Following the civil war, the pro-treaty nationalists formed the Cumann na nGaedheal political party who then governed the Irish Free State from 1923-32.[7] Economic policy sought a limited role for government and the pursuit of comparative advantage through free trade with Britain (Ó Gráda, 2011). The government's economic policy aimed to promote agriculture in the absence of a substantial industrial or services sector and the maximisation of agricultural income required free trade with Britain. The government rejected the pursuit of domestic industrial protection arguing protections would burden farmers with artificially high input and consumer prices (Kennedy et al., 1988).

Economic growth (real GNI), driven by agricultural output, was low or contractionary during the early years of independence and coincided with negative GS rates. Viewing the early 1920s through the lens of sustainable development amplifies

[6] The estimated NNS was 1% of GNI from 1922-32. This may be understated by the procedure used to estimate NNS. Given GS rates were -10% to -30% of GNI it is unlikely any potential understatement of NNS would overturn the finding of negative savings. The earliest available official statistics relate to the late 1930s where NNS was estimated at around 4% of GNP.

[7] The traditionally conservative party later reorganised and renamed themselves Fine Gael. Anti-treaty opposition pursued a policy of abstention from parliament until the Fianna Fáil party was established to contest, and narrowly lose, the 1927 election.

the poor economic performance noted in the traditional literature. The implication is that it appears that not only was the economy growing slowly but that the manner in which those low levels of economic growth were being obtained were predicted to lead to falling welfare for future generations. Steady annual growth of 2.7 percent per year emerged from 1927-32, following a recovery in agricultural output. The government's economic policy had placed such emphasis on support for agriculture that the sector's relatively poor performance in boosting economic growth has been lamented by economic historians. Many have attributed agriculture's poor performance to a passive policy of burden prevention rather than an active policy of support (Kennedy et al., 1988). However, one would be remiss to ignore the impact of several severe negative productivity shocks such as the impact of civil war, poor harvests from 1923-24 attributable to bad weather and a collapse in agricultural prices following a boom during and after the First World War. The apparent negative outcomes from the *laissez-faire* approach to agriculture are dampened when applying the broader sustainability perspective. Total agricultural rents rose by 1 percent when comparing 1931 to 1922, although, hardly triumphant the gain in rents paints a much better picture than the combination of production and price indices.[8] Moreover, the policy incentivised farmers towards more productive pastureland and dairy production began to flourish and would dominate agricultural rents going forward. While the economic growth towards the end of the period does not appear to have been unsustainable, and thus indicative of future welfare improvements, the level of savings appears to have been comparatively low and thus not indicative of *comparative* welfare gains, as discussed in more detail in section 5.

[8] The agricultural output price index (base = 1911-13) fell from 288 in 1920 to 110 in 1931. The volume of gross agricultural output in 1924-25 was 13 per cent lower than 1912-13 and in 1929-30 it was 4 per cent below (O'Connor and Guiomard, 1985). How does one marry a stark decline in output prices and stagnant production with a rising asset value? Firstly, the land value estimates contain a narrower basket of agricultural products but more importantly, the general assessment of agricultural performance relies on price and production indices. The indices mask the dominance of cattle and pig output in terms of rents. Pastureland comprised 90% of total rents from 1922-1931 with the combined pig and cattle share at 70% of pastureland rents.

Table 2: Components of GS and GSTFP 1922-2017 as a percentage of GNI.

Time	NNS	Ag Land	Pollution	Human Capital	Oth. Natural Capital	PVTFP
1922-30	1%	(-20%)	(-2%)	2%	0%	24%
1930-40	1%	1%	(-4%)	3%	0%	15%
1940-50	2%	3%	(-2%)	2%	0%	22%
1950-60	5%	5%	(-4%)	2%	0%	44%
1960-70	6%	2%	(-7%)	3%	0%	26%
1970-80	8%	6%	(-9%)	4%	0%	30%
1980-90	2%	(-3%)	(-8%)	5%	0%	41%
1990-2000	11%	(-1%)	(-7%)	5%	0%	18%
2000-10	11%	(-1%)	(-3%)	5%	0%	n/a
2010-17	8%	1%	(-1%)	5%	0%	n/a

Protectionism and Two Wars 1932-60.

The analysis suggests another period of unsustainable development occurred with negative GS observed in each year from 1932-38 when excluding TFP growth (Figure 1 and Figure 2). GSTFP remained positive but fell considerably, on a per capita basis GSTFP fell by sixty percent to an average of €345. The 1932-38 period was termed "the economic war" after a dispute between the newly elected Fianna Fáil government and the British government resulted in a series of retaliatory tariffs being imposed by each jurisdiction. [9] The new Fianna Fáil government embarked on a radical transformation of economic policy towards self-sufficiency and protectionism and utilised the economic war to impose its protectionist platform. Irish exports relied heavily on the British market and thus collapsed.[10] Economic growth was non-existent during the economic war with economic activity contracting in four years from 1932-38. Domestic agricultural policy sought a reversal in the trend towards pastureland and provided supports to incentivise cropland production. Cropland value grew by

[9]A key Fianna Fáil campaign promise for the 1932 general election was to default on land annuities owed to the British government that were included in the Anglo-Irish Financial Agreement. The annuities arose from land acts under which the British government arranged funds for Irish tenants to purchase their holdings. In February 1923, the Irish government agreed to pay over the full amount of the annuities, making the Free State responsible for their collection from the tenant purchasers.

[10] The volume of merchandise exports would not reach its 1930 level until 1960 and the 1930 ratio of GNP to exports was not reached until 1968 (Kennedy et al., 1988)

almost fifty percent from 1932-38, but ultimately there was a considerable decline in total land value as pastureland value collapsed. Negative changes in land value drove GS rates negative. The Economic War ended in 1938 with the signing of the Defence, Financial and Trade Agreements. Given the depressing picture painted above, it may be surprising to note that Ireland is generally considered to have "won" the economic war (O'Rourke, 1991). In exchange for a once-off payment of £10 million, Britain agreed to write off all future annuity payments (valued at £5 million per year). Additionally, Britain returned the so-called Treaty Ports that allowed Ireland to remain neutral during the Second World War and the 'default' was not an issue of insolvency and thus had only a minimal impact on bond yields (O' Grada, 2011). Another apparent triumph was the sharp growth in the industrial sector where sectoral employment grew at an annual rate of 6 percent. A key structural issue for industrial development was a failure to expand into foreign markets. The structural problem would ultimately hinder the economy in the aftermath of WW2.

During the Second World War, economic survival became the focal point. The historical literature suggests most developed economies held negative savings during WW2 even when accounting for exogenous future technological progress (Blum et al 2017). It appears that Irish savings rates actually turned and remained positive during the war, boosted by agricultural exports to Britain and a large increase in PVTFP. Milk rents almost doubled during the war and milk and cattle combined began, and would continue to, dominate pastureland rents. Cropland's share of total land value increased from 10-20 percent in response to an expansion to meet domestic food demand during the war. PVTFP more than doubled from 1938-47 from a low base. A neutral stance by Ireland limited direct war damage but the country sustained substantial economic damages through import restrictions. The abandonment of protective duties in 1942 did little as by this time the economic reality was a forced reliance on domestic production. Agriculture continued to dominate the economy and as Britain faced food shortages, an apparent vehicle for agricultural expansion emerged. The expansion was constrained by the scarce availability of agricultural inputs and capital resources from abroad. Domestic agriculture was required to continue crop expansion to meet domestic demand and this negatively affected agricultural productivity. Gross agricultural output remained stagnant during the war, a significant achievement given the scarcity of inputs and prices increased

considerably (Kennedy et al., 1988). Ireland recorded a strong balance of payments surplus during the war but exports relied exclusively on the UK. A severe causality of the war was the industrial sector as it faced a dual problem of a shortage of raw materials and the import substitution policy enacted by the government. The protected industries were mainly involved in the final processing and assembly of semi-finished goods imported from abroad. Agricultural incomes would be the only sector to see an improvement during the war. Unsurprisingly, economic growth was low during the war (1.6 percent per annum) but GS remained positive, a signal of predicted future welfare improvements.

Savings rates remained positive in the aftermath of the war and, for the first time, were propelled by rising net physical capital investment. In 1948, NNS represented the largest single component of GS (excluding TFP growth). Agricultural development was constrained by the mass imposition of domestic agricultural protections across Europe. Another issue was rising pollution damages as the return of coal imports after the war coincided with a doubling of sulphur emissions from 45kt at the end of the war to 90kt by 1950.[11] Ireland had accumulated little war damage or debt and thus seemed well placed to benefit from the sharp global recovery in the aftermath of the war. The early post-war years witnessed a considerable degree of economic growth averaging 3 percent per year from 1946-50 driven largely by industrial production which grew at an annual rate of 11 percent over the same period according to the CSO Statistical Abstracts. However, several major structural and social issues inhibited Ireland's development. Ireland held an exclusive reliance on Britain for exports, and Britain was one of the most slowly growing economies in Europe. The previous decades' industrial policy hindered the potential for export market diversification as it focused on the alleviation of emigration and unemployment rather than market development. Industrial protections produced Irish industries that were small scale and technologically unsophisticated (Kennedy et al., 1988). Social issues stemmed from inadequate infrastructure and the need to address the outflow of agricultural labour as the abnormally large wartime crop production would have to fall. The policy response commenced with a large programme of public capital expenditure to provide infrastructure and employment. Rapid growth in

[11] Pollution damages had declined during the war largely due to restricted supplied of British coal. The restricted supplies of coal lead to the development of Bord Na Mona to harvest the national peat resources.

industry and manufacturing looked promising but the growth was largely a response to the domestic capital programme with little export development.

Ireland's savings rates were high during the early 1950s but this should put this in the context of a very low and contracting GNI base as well as a high level of emigration. GS rates turned negative from 1958-60 due to high pollution damages and falling land value. Sulphur emissions reached 112kt by 1959, largely due to the increased consumption of electricity, primarily produced by coal and oil. GSTFP remained positive throughout the 1950s as total PVTFP doubled in real terms from 1950-1960 and largely reflected high levels of TFP share of sustained output growth during the 1960s and 1970s. During the 1950s, education remained underfunded and underprovided and in contrast to the corporatist labour market institutions to be found in continental Europe, Ireland had a fragmented British-style trade union system incapable of delivering wage moderation in return for high investment (Crafts and O'Rourke, 2013). A further structural barrier remained as even if wage moderation could have been delivered, domestic firms were unproductive and focused on the domestic market and foreign firms were discouraged from investment. The conventional investment that did occur was often directed towards unproductive use and thus conventional savings were invested in low-yielding projects for political purposes (Crafts and O'Rourke, 2013). A lack of direction on industrialisation came to a head in 1951 as a large current payments deficit coincided with reduced capital inflows, as Marshall Aid funds were exhausted (Kennedy et al., 1988). The government introduced special import levies to tackle the trade deficit but this depressed economic activity. Two severe economic contractions occurred during the 1950s and the economy was in a dire state when the government introduced the 1957 austerity budget.

Reassessing Ireland's economic development during the 1932-60 period again amplifies Ireland's poor economic performance in terms of growth. Just as in the early 1920s, low levels of economic growth led to low levels of welfare for the current generation and low and negative savings for much of the period offered a bleak picture for future generations. A brief period of rising GS was observed during and in the aftermath of the War and GSTFP was persistently positive from the mid-30s but again, as in the late 1920s, these savings were unlikely to have been sustained long

enough or been large enough to indicate a likely future improvement in comparative welfare. The savings estimates thus appear to provide empirical support for the view that poor economic policies led to an archaic institutional framework that hindered Ireland's economic development (see section 5).

The First Development Phase 1960-79

Ireland's first development phase occurred from 1960-80 as dated by the traditional literature. The period may be characterised as a general weakly sustainable path where natural capital degradation (pollution) was offset by increased physical capital investment and technological advancement. GS per capita rose from -€50 in 1960, to €2,000 by 1978 (Figure 1). GSTFP per capita reached €6,500 by 1978. PVTFP in absolute terms more than doubled from 1960-80. The large growth in PVTFP is discussed in section 5. NNS grew from 2 percent to 15 percent of GNI over the period (Table 2). Educational attainment rose rapidly, on foot of a belated introduction of universal free secondary education in 1967. Education expenditures increased fivefold in real terms from €430 million (2000 prices) in 1960 to €2 billion by the end of the 1970s. The total asset value of agricultural land doubled in real terms from €30 billion to a peak of €60 billion in 1979 driven by sharp growth in milk and cattle rents. The underlying dynamics of GS are important to consider during this period as economic growth was strongly coupled with pollution damages. Pollution damages peaked at 10 percent of GNI in 1979 with sulphur emissions at 229kt. Electricity generation was heavily reliant on fossil fuels and peat in particular, from the 1970s contributing to the sharp increase in sulphur emissions (CSO, 2000).

Just as Milton Friedman suggested, "only a crisis—actual or perceived—produces real change" (Friedman, 1962). With Ireland's economy in crisis economic policy shifted back to free trade. A publication in 1958, led by the newly appointed secretary to the Department of Finance T.K. Whitaker and titled *"Economic Development"* offered a clear and targeted plan to encourage free trade through Foreign Direct Investment (FDI) to drive export-oriented growth (Department of Finance, 1958). Furthermore, a specific set of investment proposals aimed to maximise the export potential of the various domestic economic sectors. One may view the government's *"First programme for Economic Expansion"* as a moderate

version of *"Economic Development."* Ireland's ascension to the European Economic Community pushed further liberalisation. Ireland joined the EEC in 1973 on the back of two unilateral reductions in tariffs in 1963 and 1964 and the Anglo-Irish Free Trade Area Agreement (AIFTAA) in 1966. A slow-down followed the first oil price shock in 1973 but the recovery was strong. Government policy aided growth through "benign macroeconomic management" and by addressing the persistent structural issues from the previous decades through greater openness to foreign markets and lesser dependence on Britain (Honohan and Walsh, 2002).

The first development phase is often lamented by economic historians as although the Free State experienced its first period of sustained economic growth (average real GNI growth of 4 percent per annum from 1960-80), Europe was booming and Greece, Portugal, and Spain all experienced economic miracles.[12] It would not be until the 1990s that Ireland experienced economic convergence. The first development phase may have been disappointing in terms of relative output growth but the period saw the first sustained and persistent increase in both GS and GSTFP, a strong signal that future welfare improvements were to be expected. Importantly, a prediction of a comparative welfare gains were signalled as it appears that Ireland held a sustained period of comparatively large savings rates for the first time (section 5).

Downturn 1980-87

Ireland's first development phase ended after the second oil price shock in 1979 sparked a global recession and exposed fragile public finances. GS turned negative from 1980-88 and was attributable to a collapse in NNS coupled with declining land value. There were some positive developments during the economic downturn and these included a large decline in pollution damages from their peak in the late 1970s and the EEC share of manufacturing exports surpassed the UK share in 1985 for the first time. GSTFP remained positive but declined severely to a trough of €1,000 per capita in 1991 and a savings rate of 7 percent of GNI, its lowest level since 1936

[12] Fitzgerald (1999) attributes the underperformance to three key reasons 1) Balance of payments issues 2) delayed liberalisation and 3) continued dependence on the poorly performing UK the time.

(Figure 1 and Figure 2). The stark decline in PVTFP is explained by large negative annual TFP growth from 2005-11 at an average annual rate of -3 per cent.[13]

The initial policy response to the first oil price shock in 1973 by a newly elected Fine Gael/Labour government was expansionary and saw the current budget deficit and exchequer borrowing requirement (EBR) rise to 7 percent and 16 percent of GNP respectively by 1975. The government took steps to reign in the public finances and the current deficit fell to 3.8 percent and the EBR to 10 percent of GNP by 1977 (Kennedy et al., 1988). In 1977, a newly elected Fianna Fáil government followed a demand management approach to abate high unemployment through a public investment programme of dubious long-term value and fiscal stimulus (Kennedy et al., 1988). By 1979, the current budget deficit and EBR had returned to their 1975 levels of GNP. The economic performance of Ireland during the 1980s was poor both in terms of conventional growth and in terms of sustainable development. Economic growth averaged 2.3 percent per annum from 1980-81 but this was fuelled by an unsustainable consumption boom driven by fiscal stimulus. Growth was negative from 1982-84 and averaged -0.3 percent per year from 1982-87. Given the large and sustained savings during the first development phase, a strong welfare improvement might have been expected during the early 1980s. It appears poor fiscal management may have delayed the predicted welfare improvement signalled by the large GSTFP rates recorded during the mid to late 1950s and beyond. In this context, the severe economic contraction might be viewed as a negative exogenous shock to current welfare.

The Second Development Phase 1987-2007

The 1987-2007 period can be characterised as a second development phase that differed from the typical weakly sustainable path that Ireland appeared to follow from 1960-80. Savings rates increased linearly up to 2005 during a second distinct development phase that one may view as a type of Environmental Kuznets curve (EKC) path. On this path natural capital improvements (driven by reduced pollution damages) coincided with increased conventional capital investment and rapid

[13] Trend TFP growth is used to compute the PVTFP values, extracted by a Kalman filter. Applying a HP filter to extract PVTFP the impact is less severe; GSTFP per capita fell to €3,000, a savings rate of 22 per cent of GNI (Figure A.3).

economic growth. GSTFP per capita data stops in 1997 where it reached a new peak near €8,000. GS per capita increased from €1,000 in 1987 to €4,000 by 2005 with new peaks recorded in each year from 1996 to 2005. Sulphur emissions fell from 180kt in 1987 to 61kt by 2005 and drove the reduction in pollution damages. The fall in sulphur emissions was a result of market-based incentives, structural changes and environmental policy (McGrath et al., 2019). Total annual environmental damages reduced from 8 percent of GNI to 3 percent of GNI by 2005 (€4 billion to €3 billion in constant prices). The EKC type path is dependent on the aggregation of the pollutant damages and driven solely by a rapid decline in sulphur damages. Sulphur damages fell from €3.3 billion to €1.8 billion in constant prices and annual CO_2 damages increased from €500 million to €1.3 billion over the same period. McGrath et al. (2019) examined Ireland's GS from 1990-2016 and accounted for an additional six air pollutants and found the same key result of a sharp fall in total environmental damages during the economic boom period. A considerable rise in NNS aided the reduced pollution damages to drive GS upward. NNS increased in real terms from €2 billion in 1988 to €7 billion by 1995 and €15 billion by 2000. Education expenditures remained steady at 5 percent of GNI and rose in real terms. Changes in agricultural land value declined but was a relatively small component of GS at an average of -1.2 percent of GNI.

Towards the end of the 1980s, Ireland's economic position was, as in the late 1950s, in crisis and once again, the recovery from the crisis would pave the way for another 20 years of sustained economic growth. The government made large cuts in public expenditure from 1987-90 to address the public finance crisis. Ireland received international attention as a potential case of an expansionary fiscal contraction (EFC) as fiscal austerity coincided with strong real GNI growth of 4 percent per annum.[14] Rapid growth continued and within a decade, Ireland experienced rapid economic convergence during a period referred to as the "Celtic tiger". Real GNI almost doubled from €64 billion in 1995 to €116 billion in 2005. Within a decade, Ireland achieved parity with not only the UK but also the rest of Europe and OECD (Honohan

[14] Conventional wisdom suggests a fiscal consolidation will contract real aggregate demand. It has been argued that this conclusion is misleading as it neglects expectations of future policy. If the private sector views the consolidation as a signal that the output share of government will be permanently reduced then households may revise estimated permanent income upwards and raise current and planned consumption (Giavazzi and Pagano, 1990). Ireland's EFC is debated as macroeconomic policy was coupled with favourable international developments that supported a fall in interest rates and consumer prices (Bradley and Whelan, 1997).

& Walsh, 2002). Given the speed of growth, many questioned the impact on environmental quality and sustainability (Pepper, 1999; Clinch, 2001). The analysis here suggests that rapid economic development and substantial declines in total environmental damages can occur concurrently.

Convergence marked a historic landmark, as virtually from independence, Ireland had been a European laggard in growth terms and output per capita had remained consistently at 60 percent of the British level. That Ireland had converged is not, in and of itself, surprising as the neoclassical growth model predicts income convergence amongst economies with similar characteristics. The peculiarity in Irish economic history was the lack of convergence during the first development phase from 1960-80 and the rapidity of convergence during the 1990s. The Celtic Tiger was a very different animal from its Asian counterpart and also contrasts quite strongly with Golden Age European growth (Crafts, 2008). Ireland's labour productivity growth was a good deal lower, mainly because of a small capital deepening component. TFP growth was strong but relied on ICT production based on an exceptional ability to attract American firms (Van Ark et al., 2002). Another key feature of the Celtic Tiger was that population growth was outstripped by growth in employment, unemployment fell, female participation rose, and immigration returned. Irish growth thus benefited from a very elastic labour supply (Barry 2002). The debate surrounding the sources of the Celtic Tiger has tended to revolve around two dominant hypotheses with obvious overlaps. The first is delayed convergence that argues that it was due to poor economic policies and institutions such as a delayed adoption of free trade post-WW2 and slow educational improvements that prevented convergence during the first-development phase (Ó'Gráda, 2002; Honohan and Walsh, 2002). The second is the regional boom argument that argues Ireland is better viewed as a regional economy that experienced a sharp regional boom during the Celtic Tiger period fostered by foreign direct investment underpinned by low corporation tax rates and membership of the EU (Krugman, 1997). Both sides of the debate largely support the view that a poor institutional framework prevented relative income gains during the first development phase. Ireland's convergence and the novelty of Ireland's experience is discussed in terms of GS by examining comparative economic history in section 5. In short, the savings recorded during the first

development offered a clear prediction of a sharp relative rise in welfare during the Celtic Tiger period.

Downturn and Recovery 2008-17

Ireland suffered a comparatively large recession from 2008-11. GNI contracted at an average annual rate of 3 percent during the downturn. Savings rates declined considerably as NNS collapsed from €13 billion in 2007 to an average of €2 billion from 2008-12 but GS remained positive due to the continued fall in environmental damages, increased education expenditure in real terms and a positive change in agricultural land value. Ireland's growth performance during this period was so poor that it was placed in the category of PIIGS (Portugal, Ireland, Italy, Greece and Spain). However, Irelands GS rates compared favourably against the World Bank's ANS rates for the PIIGS and many other nations during the downturn. Ireland's average GS rate from 2008-2012 was found to be at 8 percent compared with Spain 7 percent, Italy 4 percent, Portugal (-2 percent), Greece (-8 percent). Ireland's ANS rate was 9 percent over the same period.

Honohan (2009) argues that one might think of Ireland's growth post-2000 being artificially high and held up by a strong global economy. The world recession then acted in reverse as a severe negative shock and domestic policy had left the economy in a vulnerable state. A policy of fiscal austerity coupled with wage and price deflation (internal devaluation) attempted to tackle the economic crisis. Wages in the private sector remained stable from 2008 while price inflation was lower than in the euro area for many non-labour categories, such as utilities, transport and communications. The export performance was relatively strong and the current account moved into surplus by 2015 (McDonnell, 2015). Ireland's economy recovered to growth from 2012. Real GNI grew at an annual average of 10.4 percent from 2013-18. Questions surround the true extent of the "recovery" amid claims of "leprechaun" national accounting caused by apparent distortions from multi-national corporations (Fitzgerald, 2019). Modified GNI (GNI*) is an indicator that was recommended by the Economic Statistics Review Group designed to exclude those

distortionary globalisation impacts and is published by the CSO. GNI* suggests an average growth rate of 5.5 percent per year over the period 2012-17.[15]

Another area of interest relates to how "genuine" were the high rates of GS during Ireland's housing bubble as well as the aftermath of the recovery. The "true" Celtic Tiger arguably occurred from 1994-2001 driven by exceptional export-led growth with moderate wage and price inflation, structural funding from the EU and healthy public finances before being replaced by a credit-fuelled construction and consumption bubble (Honohan, 2009; McDonnell, 2015). McGrath et al. (2019) discuss how NNS reflected the large and rising "dwellings" component of gross domestic fixed capital formation (GDFCF). To construct GS, market prices approximate the correct shadow prices of capital assets but as the experimental economics literature shows durable asset markets such as housing may be susceptible to "irrational" bubbles (Smith et al., 1988). Using market prices to approximate shadow prices is a well-documented limitation of GS estimation (Hanley et al., 2016). One way we might think about these bubbles is that with the "correct" shadow prices, NNS and consequently GS would have been lower during the boom from 2001-07 but higher during the "pessimistic" post-crash period following the prolonged bust in house prices. It does not appear that making these adjustments would change the overarching story of the period (especially if TFP growth was added). Irish GS is still likely to have "genuinely" increased from 2001. GNI growth during the recovery period was converted into a large increase in NNS that was far less reliant on building and construction ("dwellings" represented 10 percent of total GDFCF compared to as much as 40 percent during the boom). Environmental damages continued to decline and these positive factors outweighed declines in real education spending towards the end of the observed period. Large increases and new peaks in GS per capita were found from 2014-18 and thus a prediction of rising welfare for future generations.

[15] Utilising GNI* to construct GS savings rates results in higher GS rates being observed as GNI* is less than GNI and GS is unchanged. Utilising GNI* leads to implausible and negative PVTFP estimates during the 1990s particularly when trend TFP is extracted using a Kalman filter. This is largely because as Fitzgerald (2019) notes, the growth figures for individual years look distinctly odd and thus limit the practical usage of GNI* on an annual basis for the empirical application of GS and GSTFP.

Notional estimates of Post Famine and Pre-Independent Ireland 1851-1922

As detailed in section 3, tentative estimates of Ireland's GS are constructed from 1851-1922. Due to data constraints, TFP growth and human capital accumulation have been omitted, both of which would increase GS, ceteris paribus. Given these limitations, Irish GS averaged 2 percent of GNI from 1851-1922 but was highly volatile. Negative savings rates were recorded 40 percent of the time (Figure 3). There appears to have been several prolonged periods of unsustainable development; 1860-66, 1880-1884, 1895-1902, 1906-1910 & 1919-1922. Changes in agricultural land value drive the GS estimates. Concerning the other components of GS, NNS were estimated at 0.6 percent of GNI. Copper dominated subsoil asset depletion and averaged 0.03 percent of GNI. Pollution damages averaged 0.04 percent of GNI.

The last major famine in Western European history occurred in Ireland from 1845-49 and was the result of a potato blight. A comparative perspective of the Irish famine can be found in Mokyr and O'Gráda, (2002). Potatoes were key to the pre-famine economy and were a major source of savings as individuals used them as feed for livestock that was then sold in summer when the potato crop from the previous autumn was exhausted. In the short-run, the famine caused farmers to consume their livestock capital. In the longer run, the structure of agriculture began to move away from crops to pasture. A structural change in agriculture can be seen clearly as pastureland had accounted for 68 percent of total rents in 1851 and rose to 87 percent in 1921. The value of the pastureland stock rose from €13 billion (constant 2000 prices) to €33 billion by 1921 while the cropland stock value fell from €7 billion to €5.5 billion over the same period. Of the pastureland rents, cattle's share rose through time from 27 percent of total pasture rents in 1851 to almost half in 1921. Pig and milk share both declined over time from one-third each in 1851 to one-quarter and one-fifth, respectively.

Another structural change occurred in labour markets as post-famine foreign labour market conditions impacted Irish labour costs much more than the price of the potato that had dominated pre-famine (O'Rourke, 1994). Early Irish economic historians argued, on Malthusian grounds, that the famine merely exacerbated an inevitable decline in population. O'Rourke (1995) and later Irish historians instead interpreted the famine as a major negative shock. There is evidence to suggest that

Irish living standards exhibited a strong catch-up post-famine. However, one must parse the evidence within the context that Ireland lies at the periphery of the development of historical national accounts. Any pre-1930s statistics must be interpreted with a high degree of caution. The "optimistic" story is that Irish living standards converged strongly between 1850 and 1914 to not just Britain but the rest of Europe and the United States (Kennedy et al. 1988; O´Rouke, 1995; O'Gráda and O'Rourke, 1997; Geary and Stark, 2002; Anderson and Lennard, 2019).[16] There is disagreement over the forces underlying the convergence and in particular the role of emigration. Some argue emigration played a key role (Williamson, 1994; Boyer et al., 1994; O'Gráda and O'Rourke, 1997; O'Rourke and Williamson, 1997). Others have argued that other structural factors played the dominant role (Cullen, 1972; Geary and Stark. 2002). Another debate surrounds the reason for emigration, modern historians argue emigration was largely a result of attractive relative wages from abroad (O'Rourke, 1991; Hatton and Williamson, 1993) rather than Marx's view of destitute agricultural workers being forced off the land due to the structural change in Irish agriculture.

Geary and Stark (2002) allocate aggregate estimates of GDP across component regions thus estimate Irish GDP as a region of the UK and find that capital deepening and TFP growth likely played the key roles in convergence. A puzzle emerges; how does one marry Irish living standards converging to the rest of the world with highly volatile GS during the post-famine period? It might be tempting to suggest that the estimates contradict the story of relative welfare convergence post-famine but recall from Geary and Stark (2002) it is likely that capital deepening and TFP growth were the key drivers of convergence. The GS estimates do not include TFP growth or human capital accumulation and likely understate NNS given the knitting procedure employed. Further research in this area would be a welcome addition.

[16] Optimistic in the sense that living standards converged, however one of the likely main drivers of convergence was mass emigration, certainly a less than ideal convergence mechanism (O'Gráda and O'Rourke, 1997).

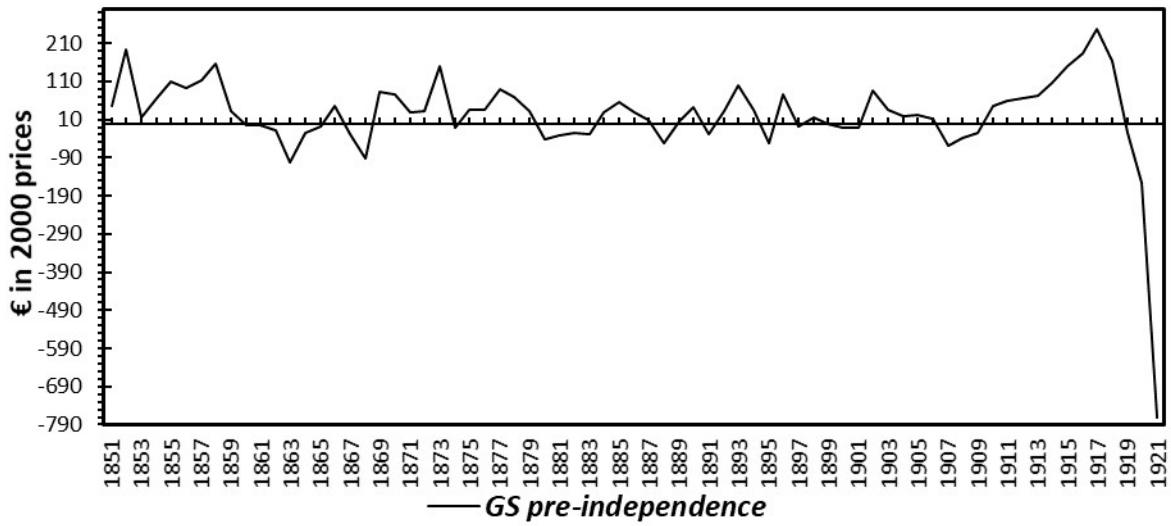

Figure 3: GS estimates 1851-1922

Revisiting Ireland's Convergence - Pinpointing a Great Transition.

The conventional Solow-Swan model of economic growth predicts conditional convergence for economies that hold similar characteristics and forms the basis for the delayed convergence hypothesis. The delayed convergence argument holds that bad economic policies held back the institutional framework required for Ireland to converge during the European Golden Age. Bad policies often cited include the prolonged pursuit of autarky, underinvestment in human capital and misguided fiscal policy (Ó Gráda and O'Rourke, 1996; Honohan and Walsh, 2002). Once the mistakes of the past were corrected, Ireland then converged rapidly given the favourable economic conditions during the 1990s. The regional boom argument stems from Krugman (1997) who stressed the role of economic geography and that Ireland straddles the facets of both a national and a regional economy. A regional boom can cause large swings in economic performance. The key factors in the regional boom story were EU membership, the low rate of corporation tax and an increase in FDI flows particularly from the US (Barry, 1999). The regional boom and delayed convergence arguments share many overlaps, the main disagreement surrounds the extent to which the process of convergence is automatic (Ó Gráda, 2002; Barry, 2002). Both sides of the debate largely support the view that a poor institutional framework hindered development.

GS theory allows us to reassess Ireland's economic convergence (and earlier failure to converge) through the lens of sustainable development and in particular by examining the great transition hypothesis proposed by Lindmark and Acar (2013). Little is known of the development paths followed by the economies that converged to high-income status during the mid to late twentieth century. There is a limited but growing literature on long-run GS studies that have tended to examine large early developed economies such as Great Britain (Greasley et al., 2014), the USA (Greasley et al., 2013), Germany (Blum et al., 2019) and Australia (Greasley et al., 2017). One exception is the study by Lindmark and Acar (2013) who examined the development of Sweden, an economy that converged during Europe's Golden Age. Sweden offers a good comparison for Ireland as both countries held similar levels of income per capita in 1922 based on the Maddison project dataset and to our knowledge, it is the only other historical GS study to include local air pollution. Lindmark and Acar (2013) found Sweden to have held consistent negative savings from 1850-1910 before a period of economic shocks (WW1 and the Great Depression) and then a smooth transition to persistent positive savings from around 1930. The transition from a development path of persistently negative savings to consistently positive savings was termed the "great transition of Swedish sustainable development." The author's suggested that each modern developed economy underwent their own great transition in conjunction with or preceding convergence.

The underlying dynamics of Sweden's great transition were that of a general weakly sustainable path. Increased conventional investment and human capital accumulation compensated for increased natural capital degradation (pollution damage and timber depletion). Sweden's GS rose in a sharp linear fashion from 1930-50 up to 25 percent of GDP and the GS rate stayed above 20 per cent of GDP for much of the remaining period studied by Lindmark and Acar. As discussed in section 2, a key theoretical proposition of the GS indicator is that it is a forward-looking indicator of future welfare as measured by the PV change in future consumption. The empirical literature has shown GS to be a generally good forward-looking indicator of welfare over twenty to thirty years (Greasley et al., 2014; Hanley et al., 2016; Mota and Cunha-e-Sá, 2019; Qasim et al., 2020). Sweden converged to high-income status by the 1970s placing the likely key period of Sweden's great transition somewhere from 1930-55.

Ireland's experience is certainly less straightforward than the Swedish case. Excluding TFP growth and focusing on GS since independence, no smooth great transition appears to have occurred. Persistent positive GS only emerged from the late 1980s during Ireland's second development phase. If one considers this period to be Ireland's great transition then the underlying dynamics in the Irish case differ as Ireland followed an EKC type development path. Interpreting the second development phase as Ireland's great transition is problematic as GS is a forward-looking indicator of future welfare, not an instantaneous indicator. Assuming GS is measured reasonably accurately, and the theory is correct, then the GS indicator should have signalled a rapid increase in welfare earlier. Likely, the GS measure is not accurate as it excludes TFP growth.[17] The inclusion of TFP growth within the Irish GS estimates changes the picture dramatically and results in a similar pattern to Sweden. Using GSTFP for Ireland, persistent positive savings rates emerged in both Ireland and Sweden from the 1930s. Why then did it take Ireland an additional thirty years to converge? Looking from the vantage of sustainable development, the results conform well to the general narrative of Ireland's economic history. The results suggest a tale of "missed opportunities" for Ireland in a similar manner to Australia found by Greasley et al., (2017).[18] Greasley et al., (2017) show that matching another nation's Genuine Savings rate would result in a match of the growth rate in future consumption changes. Blum et al., (2017) provide comparative data for several well-developed economies from 1900-2000 that are referred to in this study as the OECD. Pre-1950, had Ireland held higher average GS rates than the OECD economies then consumption should have grown at a faster rate than the average consumption growth of those comparators and thus welfare convergence during the European Golden Age would have been predicted. Table 3 shows that Ireland did not record substantial savings rates until the 1950s and that from 1900-46 GS and GSTFP rates were considerably lower in Ireland than in all OECD countries studied by Blum et al., (2017). Additionally, Irish savings rates appear to be much lower than Sweden's during the period of the Swedish great transition. The implication is that although

[17] TFP is more likely to be a key determinant of Irish welfare improvements than in Sweden given the findings of Lindmark et al., (2018). Lindmark and Acar (2013) did not include estimates of Swedish TFP growth in their GS estimates but Lindmark et al., (2018) find that TFP growth did not play a large role in future consumption changes in Sweden. Lindmark et. al (2018) find GS to be positively correlated with the PV change in future consumption but find much less evidence of the predictive power of GS for Sweden than is typical in the literature.

[18] Greasley et al., (2017) examined a counterfactual for Australia who were found to have considerably lower savings rates than comparator countries post 1870 and that this contributed to a relative decline in consumption per capita into the future.

GSTFP indicated no evidence of unsustainable development, and thus predicted future welfare improvements, the savings rates were too low to generate *comparative* welfare improvements during the Golden Age.

GSTFP rates appear to have been much larger in Ireland than in the OECD economies during the 1946-2000 period. Ireland did hold large savings rates during the 1950s that did not translate into a welfare convergence likely because Ireland's trend in savings was the opposite of the OECD countries from 1945-65. Irish savings rates declined from the late 1950s compared with a sharp rise in all the other OECD countries. The likely period where Ireland held a clear "savings advantage" was 1965-85 and the magnitude was likely to have been large. For example, UK GSTFP averaged 29 per cent of GDP from 1960-2000 (Greasley et al., 2014) compared with Irish GSTFP of over 40 per cent of GNI over the same period. It appears then that Ireland did undergo a great transition and the transition occurred during the first development phase. Only GSTFP is consistent with a story of relative welfare improvement as both Irish GS and NNS were consistently lower than the OECD economies throughout each period studied by Blum et al., (2017).

The PVTFP component represents the 'Solow Residual' that encompasses all factors unaccounted for in the production process, such as changes in institutions and social capital. The results suggest that institutional improvements in post-1950s Ireland likely paved the way for the large relative improvements that were observed in living standards 20-30 years into the future, as predicted by GS theory. Crafts (2002) provides benchmark estimates of an alternative development index, the Human Development Index (HDI) for many countries between 1870-1999, the absolute change in the HDI between 1950-99 is available for Ireland, Sweden and all Blum et al., (2017) countries and suggest Ireland achieved a larger absolute gain over that period than all of those countries except France. Institutional change is an attractive explanation given the sizeable jump in annual TFP rates and consequently PVTFP that coincided with a well-documented shift in economic and social policy. Irish annual TFP growth was estimated to have been 0.8 percent on average from 1923-60 and then trebled to 2.4 percent from 1960-2005. The late 1950s and early 1960s saw the introduction of export tax relief, and measures to attract foreign direct investment. From the mid-1960s trade was liberalised and EEC membership in 1973 helped to

further modernise Irish institutions. Overdue investment in human capital and educational reforms began during the 1960s as secondary school finally became available to all citizens. Key institutional reforms during the first development phase left Ireland in a position to take full advantage of deeper European integration and globalisation. The fiscal crisis of the 1980s was severe but it had the effect that that trade unions became amenable to enter into corporatist social partnership agreements. A reformed labour market coupled was coupled a surge in labour force participation from females as well as a trade friendly regime of low corporate taxes that then produced a surge of inward investment, rising TFP levels, and increased in employment during the Celtic Tiger (Barry, 2002; Crafts and O'Rourke, 2013).

The findings provide empirical support for the traditional view that Ireland's economic performance was held back by an archaic institutional framework that prevented a convergence to modern living standards during the European Golden Age. Ireland appears to have held large comparative GSTFP rates during the first development phase. The implication is that with perfect hindsight the large comparative welfare gains observed during the Celtic Tiger period would have been expected. The results reflect modern growth theory and the GS literature that places a large emphasis on the importance of including measures of exogenous technological progress within the GS model. There is now a limited literature that tests the predictive power of GS estimates and although beyond the scope of this study, important future work will be to econometrically test the key theoretical propositions of the GS model with the historical data for Ireland. The suggestion in this study that TFP growth played a large role in Ireland's welfare convergence could also be tested econometrically.

Table 3: Comparison of GS and GSTFP 1900-2000 Ireland and OECD

Economy	**1900-2000**		**1900-1946**		**1946-2000**	
percent of Output	GS	GStfp	GS	GStfp	GS	GStfp
Britain	5.5	28.6	2.4	20.1	8.07	35.1
Germany	11.3	49.6	10.1	49.3	12.3	49.8
US	8.1	32.6	8.3	38.0	7.9	34.4
Australia	6.5	24.7	5.5	25.1	7.4	24.4
France	11.6	29.1	6.3	35.5	16.4	23.7
Switzerland	17.5	45.4	13.9	54.3	20.6	38.0
OECD Avg	10	35	8	37	12	34
Ireland	**2-8**	**29-35**	**(-5)-(-1)**	**14-17**	**5-11**	**36-42**

Source: Author's calculations and Blum et al., (2017)
Notes: Irish data begins from 1922. The range of Irish estimates relates to the inclusion or exclusion of pollutant damages. Excluding pollution yields higher estimates. Blum et al (2017) do not include pollution damages thus the upper bound estimates for Ireland may offer a better comparison.

Conclusions

Relying on national data sources, this study constructed long-run GS estimates for Ireland. Constructing estimates for Ireland shows that one can provide GS estimates over the long run even for a country where there is a lack of detailed historical macroeconomic accounts. The results conform well to the general narrative around Ireland's economic history, modern growth theory and the GS literature that emphasises the importance of including exogenous technological progress within the GS model. The findings amplify the sharp contrast between pre-1960s and post 1960s economic performance noted in the traditional literature on Ireland's economic history. The study provides empirical support for the view that an archaic institutional framework and poor governance held back Ireland's economic convergence.

The traditional literature has noted how Ireland's poor economic performance in the pre-1960 period led to low levels of welfare for the current generation. Reassessing economic performance through the lens of sustainable development suggests that not only were the low levels of economic growth restricting the welfare of the current generation but also the welfare opportunities for future generations. While there were periods of economic growth in the pre-1960 period that did not appear to have been unsustainable, and thus indicative of future welfare gains, the level of the savings recorded appeared to be comparatively low and thus not

indicative of *comparative* welfare gains. According to GS theory there would have been no basis for a prediction of future comparative welfare gains during the European Golden Age and thus Ireland's failure to converge should not have been surprising in hindsight. It was only during the first development phase from 1960-80 that large and sustained savings were recorded. The first development phase is generally lamented by economic historians as a period of economic failure in Ireland but through the vantage of sustainable development this period can be viewed as Ireland's great transition period where Ireland developed along a typical weakly sustainable path and importantly held a sustained comparative savings advantage. The findings suggest that Ireland's great transition was the result of institutional improvements rather than traditional capital deepening as in the Swedish case. Ireland offers a novelty in terms of the GS literature with a second development phase from 1987-2007 where the development path represented an EKC type effect where rapid economic growth translated into large physical and human capital investment and coincided with a large decline in total environmental damages. It was only during the second development phase that Ireland achieved economic convergence.

For policymakers, the theoretical literature suggests that one cannot asses the development path of an economy with the aggregates of the SNA. Total national output can be consistently rising but that growth will not be sustainable if accompanied by the over-consumption of natural or physical wealth, and/or insufficient investment in human capital and technological advancement. Sustainable development ultimately depends on how we manage our natural resources and transform the returns from our natural environment into other types of productive assets. Ireland appears to have been successful at this task in modern times as unsustainable development, at least in the weak sense, has not been signalled for several decades. Our results are limited by the coverage and valuation of the assets included in our models. Given this limitation, it is important to stress what GS theory actually implies. If savings are persistently negative, the economy is on an unsustainable path, but positive savings are not sufficient to ensure sustainable development. A finding of low or negative savings provides a strong warning and GS can act as an informative indicator and provide a useful guide to where further analysis is required. It seems sensible to supplement GS by identifying and monitoring critical natural assets in physical terms.

Key future research will involve the econometric testing of the key theoretical propositions that underpin the GS model with our historical Irish data. Econometric tests could also be developed to test the hypothesis that institutional improvements played a large role in Ireland's relative welfare convergence. Other areas of promising future research include estimating human capital accumulation and TFP growth from 1851-1922 and the development of a broader coverage of natural capital assets such as biodiversity and marine assets, as well as the development of better measures of human capital.

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Appendix

Sensitivity Analysis

Figure A.1: GS and GSTFP per capita 1922-2017 excluding Human Capital

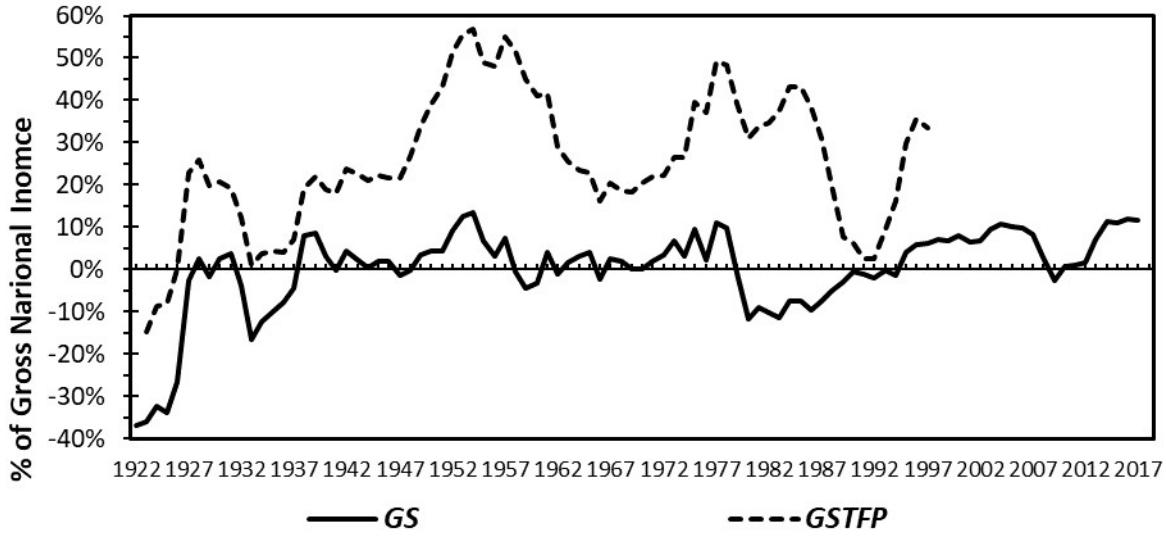

Figure A.2: GS and GSTFP as a percentage of GNI excluding Human Capital

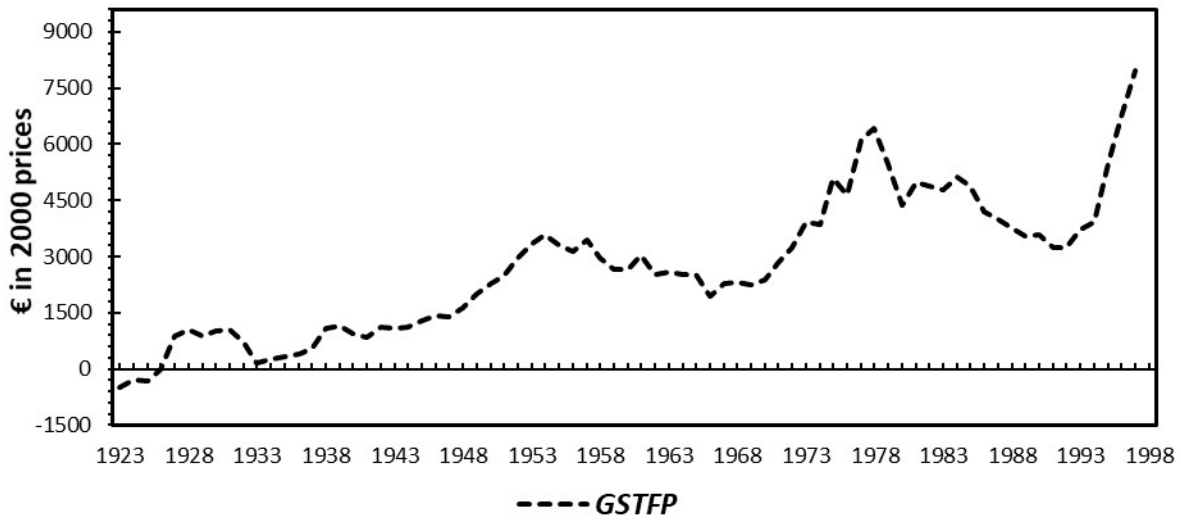

Figure A.3: GSTFP 1922-97 with HP filter to extract trend TFP growth

Data Appendix

Historical National Income Accounts: Net National Savings

There are no consistent official historical National Accounts for Ireland. Duncan (1940) published the earliest version of the accounts containing estimates of National Income only back to 1926. In 1945, the Department of Finance published nominal data for 1938-1944 and from 1951, the CSO published annually but as there have been periodic revisions to the data and methodology a "consistent" series must be knitted together using the historical publications. The key aggregate needed for the GS estimates is Net national savings (NNS). For 1995-2017 NNS are from National Income and Expenditure 2018. The CSO provide data from 1970 to 1995 as a "historical" series. These two sets of accounts provide an overlapping set of 1995 estimates. To deal with the inconsistency the 'modern' 1995 figure is taken as correct and the two series are knitted together using the old growth rates. For earlier years, the latest volume of NIE giving data for an overlapping year is used to carry back the series. This is the same procedure as Fitzgerald and Kenny (2019), who provided estimates of National Income and GNP back to 1926. To estimate NNS back to 1922 growth rates of National Income from Duncan (1940) and GDP from Stuart (2018) are used with an assumption that changes in NNS mirror changes in GDP. To construct estimates of NNS pre-1922 data on Irish GDP growth from the "Millennium of macroeconomic data for the UK" dataset is used (Thomas and Dimsdale, 2017).

Natural Capital

Pollution Damages

Historical estimates of CO_2 (Gütschow et al., 2019) and SO_2 (Smith et. al., 2012) are available back to 1850. Carbon damages in 2010 prices range from €5/tCO_2 to €38/tCO_2 and CO_2 damages are discounted at 3 percent per year (World Bank 2018). SO_2 damages reported in the results are the upper bound estimate from EEA (2014). The sulphur damage cots is then deflated with a real wage index constructed from CSO data on historical wages supplemented with data from Census of Industrial Production publications. When lower damage costs from the literature are employed the results do not change much. GS per capita is illustrated below where GS takes the upper-bound estimate (€39,000 for the year 2016) from EEA (2014) compared with

GS2 where we take the lower bound estimate (€13,000) from EEA-2014 and GS3 where the value from the public spending code (€7,000) is taken.

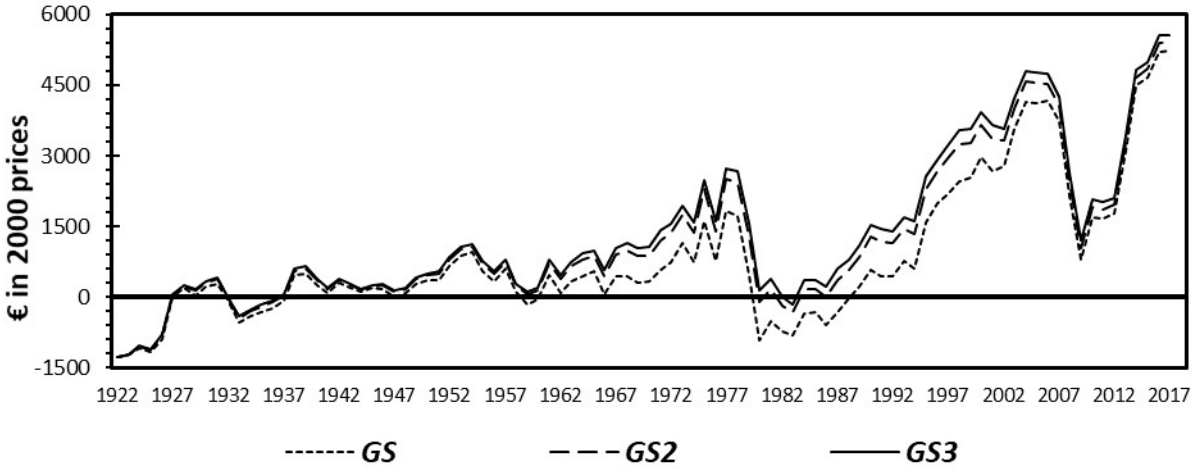

Figure A.4: GS 1922-2017 with differing pollutant damages

Agricultural Land Value

The total stock value (V_t) is calculated as the present value of returns to both pastureland and cropland $V_t = \overline{R_t} + \frac{\overline{R_t}}{r-g}$. Where $\overline{R_t}$ is the lagged, five-year moving average of the total value of rents from the agricultural output, r is the annual discount rate (4 percent) and g is the annual growth in agricultural productivity of 0.97 percent for crops and 0.89 percent for livestock (high-income countries in World Bank, 2018). Land area is assumed constant. Cropland includes oats, barley, potatoes and wheat. Pastureland includes milk, cattle, pigs and sheep. Data on production and producer prices are constructed based on data from the CSO Statistical Abstracts ("Agricultural Output") and historical Agricultural Statistics publications. The annual rents for cropland products are $R_{k,t} = q_{k,t} * p_{k,t} * a_g$. where $R_{k,t}$ are rents from crop k harvested in year t, $q_{k,t}$ denotes production for that individual crop, $p_{k,t}$ is the unit price and a_g is the average rental rate assumed constant at 0.17 (the western Europe rate from World Bank, 2018). Livestock rents are calculated as $R_{k,t} = (q_{k,t} * p_{k,t} * 2a_g)e_e + (q_{k,t} * p_{k,t} * a_g)(1 - e_e)$. Where R, p, q and a are as already defined, e_e is the share of livestock production in extensive systems (FAO Global Livestock Environmental Assessment Model). The rental rate is assumed to be twice that for intensive systems. The same rental rates assumed for crop products are assumed for livestock products in intensive systems.

Minerals

Minerals include zinc, lead, silver, barytes, gypsum and copper. An estimated joint extraction cost for lead, zinc and silver of $475-$525 per tonne in 2008 forms the basis for all production costs. The mid-point of the joint cost is converted to euro and distributed in proportion to lead, zinc and silver extraction in 2008. Production costs are then deflated by constructing a historical mining earnings index from CSO data thus a nominal series for lead zinc and silver production costs is obtained. Prices for all minerals are from the USGS minerals database and the World Bank's commodity database. Annual unit rents are calculated for lead zinc and silver for each year and average rents then proxy the rents for barytes, gypsum and copper. The lifetime of lead, zinc, silver and gypsum set to 2026 the expected closure of the largest zinc-lead mine, for copper and barytes their respective final year of extraction is used.

Energy Resources

Coal production is taken from DCCAE, prices and costs (labour costs) are taken from the CSO Statistical Abstracts and the Census of Industrial Production publications. The lifetime for coal is set to 1993, the final year of extraction. Peat depletion contains both private harvest and Bord na Mona. Annual unit rents are calculated using Bord Na Mona's annual accounts and cover 1947-2017 following Ferreira and Moro (2011). Private peat harvest is taken from the CSO Statistical Abstracts. Private peat rents are assumed to equate public rents, for years prior to 1947 the 1947 unit rent is used. For a couple of years, there is a negative unit rent, in this case, the average rent from the previous five years is used. Natural gas rents are taken from World Bank (2018) and then the depletion value is calculated using the simple net present value approach with the lifetime set to the expected end of the Corrib gas stream.

Human Capital

Human capital is net education expenditures from the CSO Statistical Abstract publications and are available back to 1926. Data for missing years was linearly interpolated.

Growth Accounting

To calculate Q_t the starting point is the conventional growth accounting framework with a Cobb-Douglas production function $Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$. Where Y_t is output (Gross National Income), A_t is TFP, K_t is physical capital input, L_t is labour input and $1-\alpha$ is labour's income share. No official physical capital stock estimates exist for Ireland thus the initial stock K_t is estimated using the perpetual inventory method $K_{t-1} = (1-\delta)K_t + I_t$. Where the depreciation is rate is δ and I_t is gross capital formation (GCF) in year t.[19] The initial capital stock is chosen such that the capital-output ratio in the initial period equals the average capital-output ratio from 1922-1932 (Kehoe and Prescott, 2002). The labour series is calculated from data on working-age population and participation rates constructed using CSO data and Census publications where missing data is linearly interpolated.

[19] Gross Capital Formation (GCF) in 2000 prices is estimated using the knitting procedure described above for NNS. δ is assumed constant at 6% as postulated by Byrne and McQuinn (2014)


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