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Abstract

Are natural resources a curse or a blessing? The answer may depend on how natural wealth is managed. By transform a temporary windfall into a permanent stock in the form of a sovereign wealth fund, resource-rich states can avoid volatility and Dutch Disease effects, save for future generations, and invest locally. Herein we review the theory behind these resource funds, and explore the empirical evidence of their success. Our review is complemented by case studies that highlight some of the more nuanced features, behavior, and effects of resource funds. While the theoretical work highlights prescribing funds as remedies is situational, existing empirical work to complement these prescriptions is minimal. We discuss possible reasons for this, and in doing so highlight some of the challenges associated with empirical research in this area and discuss possible paths forward.

Keywords: Natural Resources; Sovereign Wealth Funds; Survey

JEL Classification: Q32; Q33; Q38; Q43; Q48

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1 Introduction

Over the last half century, Sovereign Wealth Funds (SWF) have become a major policy instrument for countries rich in natural resources to capture and invest these resource rents for the public good of its citizens. As a natural resource like oil and coal is extracted and sold, the government captures some of the rents and grows the fund by either taxing a private seller or diverting some fraction of the public sale into the fund.[1] A natural-resource based SWF serves three main purposes: (1) savings funds as a way to address intergenerational equity from the depletion of non-renewable resources, (2) stabilization funds for current generations, and (3) reserve investment and strategic development funds to spend on human, natural, social, and physical capital. Examples abound. Norway has created a $1.3 trillion SWF from sale of its oil reserves; Kuwait, Abu Dhabi, Qatar, Saudi Aribia, and other oil-rich countries have established their own multi-billion-dollar SWFs; in the USA, Alaska has established an $81 billion SWF from oil sales, Wyoming has an $25 SWF from coal, oil, natural gas sales, and New Mexico has a $34 billion fund mostly from oil.

In the case of these resource-rich countries, provinces, or states, SWF have emerged as one tool to help address the long-standing question as to whether natural resources promote or hinder economic growth and development. Recall the classic debate. Initially, many perceptive observers argued that natural resources should promote economic growth because resources can be used as a factor of production, or sold off and the proceeds invested locally in various forms of physical and human capital. Intuitively, this argument makes logical sense—more resources, more growth. But counter to this intuitive argument, empirical work by (**??**) found the opposite—more resources, less growth, e.g., a resource "curse". The countries most dependent on natural resources seem to grow the slowest, and this result has motivated a large literature that more generally explores the economic and political effects

[1]Not all Sovereign Wealth Funds are created from natural resource exports. Besides receipts from resource exports, other sources used to establish SWF include balance of payments surpluses, foreign currency operation, any proceeds from privatization of public assets, governmental transfer payments, and any fiscal surpluses.

of natural-resource wealth.

And while the academic literature continues to debate the pros and cons of resource wealth,[2] SWF have emerged as a promising policy tool to avoid some of the pitfalls associated with natural-resource dependence and economic growth. Herein we examine the role of natural-resource based SWF (NR-SWF) in a modern economy. The basic question that motivated this review is whether SWF should be more commonplace in natural-resource policy. People have asked whether a country or state should create a SWF for every resource it possesses, not just the non-renewable resources but the renewable resources as well, e.g., fisheries, forests, wildlife. We also wonder whether a country should create one large SWF (both resource and non-resource funded) to create a system that could support the idea of a Universal Basic Income (UBI) (see for example (**??**)). We first discuss the theoretical underpinnings of why a SWF fund is attractive to real world policy makers who are blessed with an abundance of natural resources. We then consider the empirical evidence on how well these NR-SWF have performed at achieving policy objectives. This section highlights some of the inherent empirical challenges facing researchers working in this area. We next present a set of three comparative studies on how these NR-SWF have been formed or not; been corrupted or not; and how the revenues from the funds have been distributed.

2 Theory

A theoretical literature has emerged on when, and why, governments in resource-exporting countries should establish a Sovereign Wealth Fund (SWF). The literature has focused on natural resources, rather than other sectors because of the large economic rents

[2]Theoretical evidence supports the idea of a Dutch Disease (**?**) resulting from a booming natural-resource sector, and yet, empirical evidence is weak (**?**). Others have argued that natural resources cause civil conflict (**?**), and yet, beyond case studies, this result is sensitive to modeling assumptions and specification (**?**). The interpretation of the negative relationship between resource dependence and growth has even been called into question (**???**). A more robust relationship exists between income levels and the timing of resource discoveries (**???**). Natural-resource wealth has also been shown, rather convincingly, to reduce the quality of democratic institutions and cause political corruption (**???????????**).

they generate[3]. The first question that resource-exporting governments face is how to capture the rents through taxation, which has been studied in an extensive literature that is beyond the scope of this survey (see for example (**?**)). Once the government has captured the rents, the next question is how to use them for the greatest benefit of the nation and its citizens.

In this section we outline how recent academic literature has found that SWFs are crucial for harnessing the benefits of natural resource rents, if they are tailored to the country's level of development. In doing so we draw on related reviews of the literature by (**?????**). In Appendix 1 we lay out the basic theoretical structure used by this literature, based on (**?**). Generally the literature has found that developed countries should set up a Future Generations Fund, for transforming a temporary windfall into a permanent one. In contrast, developing countries should focus on repaying debt and investing domestically, while making use of a temporary Parking Fund to avoid issues that arise from investing too quickly. This recognizes that governments face a "hierarchy of needs", and so must repay debt and invest domestically before saving abroad. All countries should save extra in the interests of precautionary savings. Stabilization Funds can be a useful tool for temporarily smoothing changes in government spending, especially when monetary policy is constrained[4], but they should not replace necessary fiscal tightening when resource prices fall.

2.1 Developed countries should save in Future Generations Funds

Once a government has received a windfall, the first issue facing policymakers is whether it should be spent or saved. The simplest setting involves the government receiving a temporary, exogenous stream of resource rents, and choosing whether to consume them, or save them in perfect global capital markets (see for example (**??**)). "Perfect markets" means that both foreign and domestic assets earn the same, constant, global rate of interest. In this

[3]Natural resource rents arise because demand is inelastic, and supply is oligopolistic and dictated by geography.

[4]For example, by use of exchange rate pegs, which are used by three-quarters of natural-resource exporters (**?**).

setting we quickly recover (**?**)'s "permanent income hypothesis": that the resource revenues should be saved to convert a temporary windfall into a permanent stock of financial assets – in the form of an offshore Sovereign Wealth Fund.[5] The government should then consume a constant amount from the windfall in perpetuity, equal to the interest on the windfall's present value, as part of recurrent spending in its usual budget process.

Even this simple setting yields some useful rules-of-thumb for how much of resource revenues should be saved in any particular year (**?**). If the resource is extracted quickly and intensely, then a greater share of the revenues will need to be saved. If it is left in the ground and extracted slowly, then more can be spent. In both cases the share of revenues that are saved should increase with time, as the government can instead spend the interest from the SWF.

The spending rule can also be expressed in terms of the size of the SWF. Under the permanent income hypothesis, spending should be a constant fraction of total wealth. Total wealth includes both above-ground SWF assets, and below-ground resource assets. In the early years of the windfall total wealth is dominated by assets beneath the ground, so spending should be a relatively high proportion of the (small) SWF. As resources are extracted and the fund grows, spending should fall relative to the size of the fund. In recent years Norway's Government Pension Fund Global, which has been described as a "model" for other funds (**??**), has done just this by lowering its handlingsregelen ("budgetary rule") from 4% to 3% in 2017 (see also (**?**)).

This simple framework also provides intuition for why SWFs in developed countries, like Norway, should invest offshore, rather than domestically. It is because it assumes easy access to global capital, so that projects that are profitable at the world rate of interest will already be financed. If the resource windfall is large relative to the size of the country, and it is all invested domestically, then this glut of savings would push the domestic return on investment

[5]This is similar to (**?**), who first argued that revenues from exhaustible resources should be invested in above-ground assets. However, he ignored access to foreign assets so the only asset available to him was domestic capital.

below that which can be achieved abroad. If capital moves freely, then foreign investors would flee the country for higher returns elsewhere. If it doesn't, then the domestic economy will see over-investment in unnecessary projects, and dismal rates of return. Investing the SWF in large, liquid, global capital markets avoids this (as well as diversifying risk, which we consider below).

2.2 Developing countries should repay debt and invest domestically

However, this assumption of perfect capital markets does not make sense for many countries. In particular, (**?**) point out that developing economies tend to have only asymmetric access to global capital markets: saving more easily than they can borrow. Therefore, developing countries are characterized by a lower capital stock, and a higher return on capital, than their developed counterparts. A massive resource discovery can alleviate some of these constraints, allowing them to repay foreign debt and invest domestically with higher returns than they can achieve abroad.

(**?**) provide a framework for analyzing this. They assume that a country's domestic interest rate increases with its level of foreign debt.[6] Countries without debt (or with net foreign assets, like a SWF) can borrow at the constant global rate, like the developed economies described in Section 2.1. Those with debt, however, face financial frictions and an increasing cost of borrowing – like a developing economy.

In this setting, developing countries can use a resource windfall to relax some of the financial frictions they face. Unlike in developed countries, policymakers in developing countries should not simply choose between spending the windfall immediately, or saving it abroad at a constant global rate. Instead, they must also consider whether to repay expensive foreign debt, or invest in domestic projects with a higher return than can be achieved globally.[7]

[6]The assumption is based on empirical evidence and could be – for example – due to risk aversion by creditors.

[7]These domestic projects will not have been financed already, because of the financial frictions faced by

The answer, as (**?**) go on to show, is for policymakers to use the windfall to gradually repay foreign debt and invest domestically at the same time. In theory the marginal benefit from spending a dollar on repaying debt should be kept the same as investing in local projects. In practice, it means starting with projects that have the highest social rate of return, while repaying the most onerous debts, and continuing until all the debt is repaid and local projects can be funded by private global capital markets. Only then, when domestic interest rates are similar to the rest of the world, does it make sense to start saving revenues for future generations in an offshore Sovereign Wealth Fund (**?**).

While debt is being repaid, and domestic projects are built, government spending on recurrent expenses like healthcare, justice and education should also be rising. This is because the resource windfall is effectively bringing forward the path of development (**?**). The difference should be largest in the short term, because the current generation is poorer than future generations. But there needs to be balance – too much consumption initially will rob future generations of development; too little will rob the current generation.

Government spending can also come in the form of direct transfers to citizens, through lump sums or tax breaks (**?**). If executed properly this can improve accountability (as the government must still rely on normal taxation), broaden access to capital, and relax absorption constraints as individuals identify the best projects (**?**).

2.3 Developing countries should also use Parking Funds

Absorption constraints describe the difficulties that an economy can face in finding productive uses for a large influx of investment that arrives all at once, particularly in developing countries. A Parking Fund allows governments to hold some of the wealth offshore until it the economy is ready to put it to use.

These constraints could be micro-economic: for example a lack of domestic talent for selecting and designing projects, a basic need for projects to be sequenced, and the time it

domestic borrowers.

takes for projects to be vetted to avoid corruption. Roads must connect to roads, and it takes teacher to produce teachers. (**?**) describes this as a need for "investing in investing".

Absorption constraints could also be macroeconomic. Rapid expenditure by the government will bid up the price of non-traded services, relative to traded goods, causing the real exchange rate to appreciate and non-resource export sectors to contract (known as "Dutch disease", see **?**). This may cause irreversible loss of some industries if there are learning-by-doing effects[8] though the effects will be mitigated if there are large domestic inputs into resource production and the windfall is due to higher resource volumes rather than prices (like Norway, see **?**). The real appreciation may occur through the nominal exchange rate, or through nominal wage and price inflation. The latter poses a challenge for monetary policy, especially in the 75% of resource-dependent countries that have some form of exchange rate targeting regime (**?**). As there is typically a delay between discovering the resource and the beginning of spending(**?**), then forward-looking prices, or the exchange rate, may appreciate in anticipation, causing a recession (**??**). If the central bank is following a simple Taylor rule, then they would tighten policy against inflation, exacerbating the recession (**?**).

These challenges can be mitigated if the government commits to saving resource revenues in an offshore Parking Fund while it scales up the country's absorptive capacity (**????**). Spreading the expenditure over time allows the government to develop the capacity needed to make the spending most effective. Committing to do so in advance prevents inflation and the exchange rate spiking, as individuals will anticipate that spending will only happen when the economy is ready. Spending that is focused on expanding absorptive capacity, especially in the tradeable sector, can diversify the economy and reduce the cost of misjudging the duration of a resource windfall (**?**).

[8] See (**??????**).

2.4 Dealing with risks through hedging and Stabilization Funds

The theory so far has treated resource revenues, and investments, as certain. In practice, of course, they are nothing of the sort. Not only is the exact size of resource deposits unknown, the price they can be sold for is highly volatile, and the return on the SWF is risky. To manage this risk governments should first try to reduce the aggregate uncertainty of the income they receive. The remaining uncertainty can be managed through additional "precautionary savings", which are treated the same as the savings in Sections 2.1 and 2.2; and as a last resort a Stabilization Fund if monetary policy cannot offset shocks to government demand.

The aggregate uncertainty in government revenues can be reduced through hedging. Small windfalls can be hedged directly using swaps and futures, as in Mexico (**?**). Larger windfalls can be hedged using the asset allocation in Future Generations Funds.[9] Beyond the diversification recommended by classic portfolio theory[10], (**?**) show that the SWF should be weighted towards assets that are negatively correlated with the resource price, while the resource remains in the ground. If transaction costs and uncertain correlations make hedging too difficult at the level of individual stocks, then they recommend doing so through the equity/bond mix. The overall share of equities (which they assume are positively correlated with the resource price) should initially be low while a lot of resource remains beneath the ground. The equity share should then rise over time, as the resource is extracted and the proceeds invested in the SWF. In recent years Norway's SWF has both reduced its allocation to the equities that are most exposed to oil prices, and increased its equity/bond mix.

Even after hedging, government revenues are likely to be volatile. The first response to this should be "precautionary savings", which arises whenever one faces a risky income stream.[11] This amounts to saving more today, to generate more interest income for generations in the future as compensation for the extra risks they have to face. It is due to

[9] See (**?????**).
[10] See (**????**).
[11] See (**????????**).

"prudence" (a positive third derivative of the utility function) rather than "risk aversion" (a negative second derivative). Governments should direct this extra saving in the ways described above: to a Future Generations fund in developed countries, or to debt repayment and domestic investment in developing ones. In both cases it should not be used to smooth fluctuations in the oil price (**?**).

In practice governments can achieve precautionary savings by heavily discounting the value of future resource revenues. As we have seen in Section 2.1, the government should aim to spend a constant fraction of total wealth, which is the sum of below- and above-ground assets (or debt). In the extreme, the bird in hand rule involves discounting below-ground assets to zero (an infinite discount rate), so that spending is a fixed share of the SWF and rises as it grows (**?**). Less extreme discounting is likely to be appropriate, particularly in developing countries where current generations are poorer than future generations (**?**).

Self-insurance differs from precautionary savings, and amounts to saving into a Stabilization Fund when resource prices are high, and drawing down on it when prices are low. If resource prices only fluctuated temporarily around a stationary long-term mean then this would be easy.[12] In practice though, resource price shocks tend to be permanent and prices follow a random walk (**???**).[13] If prices follow a random walk then it doesn't make sense to add to a stabilization fund after prices rise, or drawn down on it when prices fall, because the best forecast of the price in the future is the price today (**?**). So, if prices are low today then it is best to get used to it.

The best reason for establishing a Stabilization Fund is to smooth the government's adjustment to lower commodity prices. There are likely to be real costs associated with a sharp reduction in government spending. It will take time for prices of domestic goods to adjust, through deflation or exchange rate depreciation, and time for public-sector workers

[12] If the government also had ready access to international capital, then it could just save when prices are above average and borrow when prices are below, so that the expected value of the Stabilization Fund would be zero (**?**).

[13] There is some evidence that it is possible to beat a random walk forecast for oil prices out to 6 months, but beyond that it is better to assume a random walk (**?**).

to be absorbed into the private labour force (**??**). Monetary policy can offset such a demand shock (**?**), but if it is constrained by something like an exchange rate peg then drawing down on a Stabilization Fund can help mitigate the short-term frictions of lower government spending.

3 Empirical Evidence

The theoretical literature provides prescriptions for the settings where funds are likely to maximize welfare, but how successful have NR-SWF been in practice? This section evaluates the empirical literature on NR-SWFs to synthesize findings. [14] We focus our attention in three broad areas: the effect of funds on inter-generational wealth transfers, political institutions and economic development, and economic volatility. These roughly align with the theoretical objectives of NR-SWFs described in the theoretical section. However, in practice, funds may be established for multiple purposes, or their objectives may shift over time so aligning all empirical work on wealth funds cleaning into the objectives outlined in the theoretical section proves challenging. It is also worth briefly discussing a related literature that examines the determinants and structure of sovereign wealth funds more generally, which we start with in the following subsection.

3.1 Determinants of Wealth Funds

As discussed by (**?**), establishing a sovereign wealth fund (SWF) requires two conditions to be met. The first is *capability*. Establishing a fund that generates significant benefits—via saving, smoothing, or investment—requires significant capital that many states lack. Establishing a fund also requires *necessity* to either save for future generations, smooth the effects of outsized economic shocks, or invest locally. Based off of these criteria, (**?**) argues that "middle powers" (medium sized countries that may be relatively vulnerable to

[14] (**?**) similarly evaluate some of empirical literature on the successes and failures of sovereign wealth funds more generally and note that, "this is a severely understudied area".

international market fluctuations, but also small enough to benefit from a SWF) are more likely than other countries to establish a fund. Empirical evidence supports this theory; the probability of establishing a fund is maximized for GDP of U.S.$ 700 billion. Countries with GDP above or below this threshold are, on average, less likely to establish a SWF. Beyond "middle powers", governments of resource-rich economies are uniquely positioned to both fund and benefit from a SWF which can be used to avoid some of the economic and political problems associated with sudden natural-resource windfalls (**?**).[15] And in fact, (**?**) shows that fuel exports and natural-resource income per capita are both strong indicators of establishing a SWF (while oil reserves are not). He also finds negligible effects of political regime, government spending, or trade surplus, which is somewhat at odds with other related studies.

(**?**) analyze a panel of international data from 1998-2008 during which sixteen countries in their sample established a SWF. They find that both resource rents and GDP per capita are significant predictors for the establishment of a SWF. They also find that government spending on education and infrastructure reduce the probability of establishing a fund. This result is somewhat surprising if one considers there to be diminishing returns to a population's level of education attainment; with an already educated labor force, the marginal benefit of additional education spending is relatively small. However, this result may alternatively reflect an unwillingness (or inability) to invest in a domestic economy. As a result, a government might be inclined to invest savings abroad in a SWF due to a lack of alternative investment options. A broader set of government characteristics also matter; autocratic regimes are more likely to establish SWFs than democratic ones. Interestingly, (**?**) also show that, while natural-resource rents increase the probability of establishing a fund, this effect only exists in democratic countries. One speculative interpretation of this is that, because natural-resource funds can be embezzled by autocratic regimes, they are managed more responsibly in democracies. Finally, they also explore the effects of volatility, measured as the

[15]There is both theoretical and empirical evidence that natural-resource wealth causes political corruption both nationally (**?**) and sub-nationally (**?**).

20-year volatility of resource rents. Countries dependent on more volatile natural resources are more likely to establish SWFs, consistent with the idea that precautionary saving helps to smooth the effects of stochastic commodity price shocks.

(**?**) highlight that the determinants of SWFs differ according to how a fund is financed (e.g., commodity vs. non-commodity) and the stated objectives of the fund (e.g., saving, stabilization, domestic investment). Unsurprisingly, across all types of funds, they find that countries with excess foreign reserves are more likely to establish SWFs. Among resource-rich countries which establish stabilization funds, excess foreign reserves are less relevant. Similar to (**?**), they also find that commodity-price volatility contributes to the likelihood of establishing a fund. Many of these findings are echoed by (**?**) who examine both the establishment of SWFs and their respective size. Analyzing a cross section of data collected from the World Bank, World Development Indicators (as well as data on wealth funds taken from (**?**)), they also find that countries with current account surpluses or exports of fossil fuels are more likely than other countries to establish SWFs. In particular, a ten percentage point increase in fuel exports relative to total merchandise exports increases the probability of establishing a SWF by three percentage points. Contrary to the findings of (**?**), they also find that GDP per capita is statistically uncorrelated with the establishment of SWFs. They also study the role of governance using the Worldwide Governance Indicators constructed by (**?**) and find that countries with better governance measured in terms of government effectiveness, regulatory quality, and control of corruption are more likely to have SWFs than other countries with weaker political institutions.

The key takeaway here is that establishing a SWF requires both capability and necessity. This simple observation informs a key identification challenge: the establishment of SWFs is not random. In addition to being a "middle-power" economy, existing literature argues that having natural-resource wealth, dependence on volatile commodities, strong political institutions, and lack of domestic investment opportunities all increase the odds of establishing a fund.

3.2 Inter-generational Wealth Transfer

As described in Section 2.1, a straightforward objective of some resource funds is transfer rents from resource exploited today to future generations. We did not identify any papers that were concerned exclusively with evaluating the performance of funds in this regard. While some literature does characterize the size and longevity of funds as positive features, and these have direct implications for the intergenerational savings goals, it is difficult to evaluate this goal in isolation from other targets. The success of funds for the purpose of wealth transfer will be largely determined by the quality of governance, and therefore the empirical research reviewed in the next section on institutions is certainly relevant.

Rather than evaluating the success of intergenerational funds based simply on whether they have appreciated in size, a more important question is whether these intergenerational funds are desirable in the first place. As outlined in Section 2, when there are ample returns from making investment in the domestic economy (as in developing countries) to accelerate the growth path, the justification for investing in global markets is weaker. In theory, this principle is sound, but whether institutions are able to identify domestic investment opportunities with returns that exceed those achievable in global markets is an empirical question, one which we did not identify significant literature addressing.

3.3 Political Institutions & Local Development

Some of the most resource rich—and certainly the most resource dependent—countries in the world are also some of the poorest.[16] There is also good empirical evidence that natural resources (especially so-called, "point resources" like fossil fuels and minerals) cause corruption and degrade the quality of political institutions (??????????). There are two main reasons for this. The first is that natural-resource-extracting firms tend to earn large rents. Public officials then seek out these rents by accepting bribes in exchange for relevant

[16]Resource dependence is a measure of the relative importance of natural resources to an economy. It could be measured as the share of natural-resource production in GDP, share of exports, or as the share of natural-resource labor in the labor force, for example.

tax cuts, deregulation, or protection from foreign or domestic competition. Another, less obvious mechanism, is that resource-dependent governments tend not to tax their constituents (**??**) and taxation may be necessary for robust democratic representation (**????**).[17] Given the development and political challenges facing resource-rich economies, it is therefore not surprising that natural resource rents are used to establish investment or stabilization funds that might also bring about desired political changes by keeping large resource windfalls out of the hands of corruptible politicians. The question of whether such funds are successful in bringing about the desired political and economic changes is an important one, but also one that has received especially little attention in the empirical literature.

Examining a sample of 27 fossil-fuel-rich countries from 1996-2007, (**?**) estimates the effect of resource funds (and does differentiate between types) on three World Bank Governance Indicators.[18] Countries that have established resource funds are found to have greater Government Effectiveness, Rule of Law, and Control of Corruption. The author suggests that resource funds might therefore be a useful tool for combating political "resource curse" effects of fossil fuel production. (**?**) argues that the fund *type* rather than the simple existence of a fund is more important in determining societal governance indicators and provides some supporting evidence of this. In particular, he shows that the quality of government (measured as regulatory quality, corruption perceptions, and political stability) is higher in countries with SWFs with high Truman Scoreboard ratings.[19] It is unclear, however, whether high Truman Scoreboard ratings cause good governance, or if good governance causes high Truman Scoreboard ratings (or if a third, unobserved factor influence both). Such complications are explored in more detail in the discussion section below.

[17]The idea is that, without taxation, constituents are less interested in keeping a watchful eye on how public revenue is spent. After all, money is not fungible. People tend to be less prudent with windfall gains as opposed to hard-earned cash (**???**).

[18]See also (**?**).

[19]The Truman Scoreboard is an index measuring things like the structure, governance, accountability, transparency, and behavior of SWFs. It is designed to be a measure of the institutional quality of fund structures. According to (**?**), New Zealand's Superannuation Fund had the highest score (24) and UAE's Abu Dhabi Investment Authority and Corporation had the lowest (0.50), reflecting scores of zero for transparency and accountability, behavior, and governance.

Beyond political institutions, a small empirical literature also considers regional development effects of SWFs. For example, (**?**) analyzes a sample of 23 countries and finds that countries without resource funds grew more quickly from 2000 to 2014 than those with savings or stabilization funds. However, countries with stabilization and savings funds nonetheless experienced greater physical and human capital accumulation over that time period, respectively, which might indirectly increase economic growth. While not focused on the role of resource funds in particular, (**?**) similarly finds that terms-of-trade volatility decreases growth by lowering the accumulation of physical and human capital, and that this effect is reduced in countries with SWFs. Relatedly, Alaska's Permanent fund finances annual Permanent Fund Dividend checks paid out to every resident of Alaska (typically ranging between $1,000 and $2,000). This program has been linked to short run reductions in property crime (**?**), poverty (**?**), and income inequality (**?**).

Our review uncovered just three papers focused on the effect of SWFs on institutional quality. All three of these papers, (**??**) and (**?**) document a positive relationship between the establishment of SWFs and various measures of institutional quality. Institutional quality emerge as an important factor in the success of funds in dealing with volatility, as described in the next section. However, reverse causality is a major concern here. It is not clear from our review whether SWFs increase the strength of institutions or whether strong institutions cause SWFs. This same critique applies to much of the empirical work on the local development effects of SWFs which tends to find positive effects of SWFs on growth and capital investments.

3.4 Volatility & Stabilization

One of the greatest challenges facing resource-rich economies is commodity-price volatility, and the various economic ills associated with it. Negative commodity price shocks are associated with reduced government revenue and expenditures on important public goods like healthcare and education, and are generally associated with economic recession. But eco-

nomic booms can also have deleterious effects on non-resource traded sectors á la a "Dutch Disease" (**?**). But economic volatility more generally implies added risk and uncertainty to financial markets as well. In fact, economic volatility and uncertainty have been shown to reduce economic growth, (**??**), education attainment (**?**), and firm-level investment (**?**). Resource-induced economic volatility has been specifically linked to slow economic growth (**?**) leading the authors of that study to conclude that, "volatility is a quintessential feature of the resource curse". **?** provides evidence that pro-cyclical fiscal policies are responsible for most of the volatility that resource rich economies face. This implies governments have the ability to mitigate volatility. It is for these reasons that some resource-rich economies have established stabilization funds, to avoid the economic hardships associated with boom and bust commodity-price cycles. But have such funds been successful in stabilizing macroeconomic outcomes like employment, income, and government finances? Identifying the causal effect of wealth funds on volatility is challenging due to the endogenous nature of wealth funds (more on this later). The evidence to date is fairly scant, and what evidence does exist, is somewhat mixed.

How should volatility be measured? Because a large portion of output volatility in resource rich economies stems from pro-cyclical fiscal policies rather than the direct effects of commodity price fluctuations (**?**), the performance of wealth funds in stabilizing economic output can be well captured in looking more narrowly at their role in stabilizing government expenditures. The discussion in **?** on how to measure fund success also echoes this focus on fiscal policy, but volatility is not included in the outcome variable constructed for the empirical exercise.

Using a time series approach to identify structural breaks, there is little evidence that funds have any influence on government expenditures (**?**). There is heterogeneity in this result however, which **?** associates with changes to management rules of the funds. **?** employs a pooled cross sectional approach and finds that resource funds exacerbate volatility in government expenditures, as they provide more resources for otherwise imprudent governments.

Using similar methods and conditioning on institutional quality variables, **?** finds a positive impact of funds on a series of fiscal performance measures including non-renewable resource balance, debt, and non-resource exports. Analyzing an international panel of data, (**?**) also finds that volatility in government spending is 13% lower in countries with stabilization funds compared to those without such funds. A similar result is documented by (**?**) in an analysis of 42 oil-exporting countries. Although in this case, oil funds are shown to be fairly effective in reducing fiscal pro-cyclicality, especially in countries with sufficiently strong institutions.

? employ a fixed-effects approach on a panel of 32 oil producing countries with and without wealth funds between 1992 and 2005 to identify the potential stabilizing effect of funds on fiscal policy outcomes. A primary concern regarding the empirical identification of the effect of wealth funds on fiscal policy outcomes is that more prudent and responsible governments might be more likely to establish wealth funds as a vehicle for fiscal discipline. Rather than funds leading to better fiscal policy, it is prudence that leads to both. The fixed effects approach used by the authors corrects for the problem of unobservable characteristics ("fiscal prudence"), but only if these characteristics do not change over time. **?** addresses this concern by conditioning the estimates on institutional quality. They find that wealth funds have no statistically significant impact on fiscal policy outcomes.

? investigate a different set of macroeconomic outcomes (exchange rates, inflation, and money in circulation) and how volatility of these outcomes is affected by the presence of funds. The study uses a fixed effects approach, along the lines of **?**, estimated on a sample of 15 oil-producing countries with and without wealth funds from the period 1973-2003. They find a decrease in volatility of these macroeconomic outcomes in countries which established wealth funds. While the set of outcomes differs from **?**, these results do contrast to a degree.

(**?**) estimates the effects of wealth funds on pro/counter-cyclical government spending. The analysis uses a sample of 29 oil-rich countries, 22 of which have some form of wealth fund, and outcome data from 1980-2012. **?** finds that resource wealth funds do have the intended smoothing effect on government spending. Depending on model specification, a 1% deviation

away from GDP trend is associated with a 0.66-0.73% increase in government spending above trend. However, this effect is mitigated for wealth-fund-countries, who see attenuation between -0.5 and -0.73 (i.e. full attenuation of pro-cyclical spending). **?** notes that the timing of resource fund establishment can follow shortly after the discovery and extraction of a natural resource. As noted in Section 3.1, resource-rich countries that establish wealth funds might also systematically differ from those that do not. When these differences (particularly in institutional quality) vary over space and time and jointly determine outcomes of interest (e.g., fiscal policy decisions) and wealth fund establishment, it is difficult to identify the effect of wealth funds. To address these issues, **?** employs an instrumental variables approach and finds qualitatively similar results to the naive model specifications.

Case studies are another way in which the literature has addressed the question of wealth fund success. These studies employ a variety of empirical approaches. **?** employs time series econometric approaches and finds that Nigeria's wealth fund had no effect on government spending, while **?** uses a more qualitative approach to assess the impact of Russia's wealth fund.

To summarize, cross-sectional, panel, and time-series studies tend to document either negative or statistically insignificant effects of wealth funds on economic volatility. (**?**) was the only identified study to document evidence that funds exacerbating volatility in government expenditures. In addition to the importance of testing the theoretical prediction, there are two other important conclusions to draw from this review of the volatility literature. First, heterogeneous effects seems to be important; institutional quality is an important predictor of wealth fund success **??**. Second, empirical identification of this effect is difficult, as described by **?**, confounded by both the timing of resource discovery and unobservable country-specific characteristics.

4 Case Studies

To complement the lessons from the existing theoretical and empirical investigations, this section presents three original case studies. The first comparison (Norway and the United Kingdom) highlights some more nuanced aspects the decision to establish a fund. Next, we explore the difference in wealth fund success between Chile and Venezuela under differing levels of stewardship. Finally, two highly-rated wealth funds in the United States (Alaska and New Mexico) share similar inter-generational goals, but their methods of wealth return are distinct from each other and may lead to differences in public perceptions.[20]

As described in sections 2 and 3, wealth funds live and die by their institutional design and quality. This provides a natural basis to begin comparisons. A common measure of SWF institutional quality is the Truman Scoreboard. The Scoreboard contains 33 elements that broadly measure fund structure, governance, accountability, transparency, and use of leverage and derivatives (**?**). More broadly, the scoreboard is intended to provide a kind of benchmark of best practices. Table 1 presents ratings from Edwin Truman's SWF Scoreboard taken in 2009 and 2019 for the case study jurisdictions. Norway scores highly and is often held as a model for resource-rich economies to follow. Within the United States, Alaska's Permanent Fund and New Mexico's Investment Council both receive good scores, despite there being significant differences in fund structure and management. It is interesting to note that, even within the U.S. and Norway (where institutions are strong and somewhat homogenous), there are some differences in scores both across space and time. In fact, the difference in scores between New Mexico's fund in 2009 and Norway's fund in 2019 (14 points) is roughly equal to the difference in scores for Chili's and New Mexico's funds in 2009 (16).

[20]Even with standardized wealth fund scoring systems, it is tricky to make sense of why certain countries or states have large, successful wealth funds and others do not. A true apples-to-apples comparison is not feasible for any two wealth funds; nations have vast heterogeneity across natural resource endowment and institutional quality. The following comparisons showcase differences in wealth fund outcomes for countries or states which share, what we believe to be, relevant characteristics.

Table 1: Truman Wealth Fund Scoreboard for Case Study Funds

Country	Wealth Fund	2009 Score	2019 Score
Norway	GPFG: Government Pension Fund Global	92	100
US–Alaska	APF: Alaskan Permanent Fund	94	88
US–New Mexico	NMSIC: New Mexico State Investment Council	86	87
Chile	ESSF: Economic and Social Stabilization Fund	70	92
Venezuela	FEM: Macroeconomic Stabilization Fund	23	–

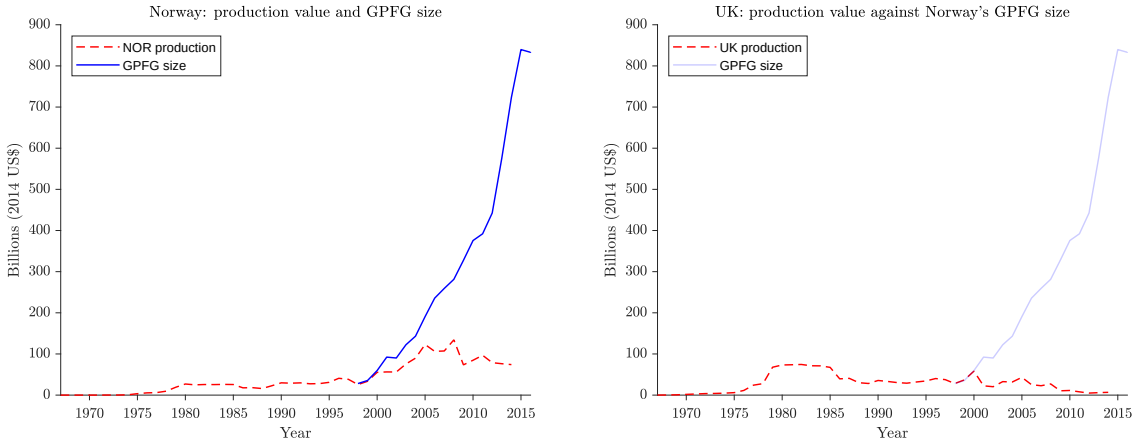
Notes: Score values are derived from index of 33 questions divided across four categories: structure, governance, accountability/transparency, and investment behavior (**?**). Truman notes significant correlations between this index and those developed by others (**?**). The maximum possible score is 100.

4.1 Norway and the UK: Choosing to invest

Norway's Government Pension Fund-Global (GPFG) is the largest natural-resource-funded SWF in the world. Founded in 1990, the fund was intended to smooth fluctuations in oil revenue and provide benefits to future generations from resource windfalls (**?**). The latest annual report places the GPFG's holdings at almost NOK 11 trillion, over US$1.2 trillion—this works out to more than US$240,000 per Norwegian resident. This fund is the only one to achieve a perfect score in Truman's SWF scoreboard (**?**).

Few countries have been as heavily endowed with hydrocarbons as Norway. One interesting (and somewhat surprising) exception is the United Kingdom, which also sits adjacent to the oil and gas-rich North Sea. The British and Norwegian resource basins have produced

roughly similar quantities of hydrocarbons (calculations based on data collected from (**?**). So why doesn't the UK have a US$1.2 trillion wealth fund? One reason is that hydrocarbon revenue in the U.K. was transferred directly to residents of the U.K. in the form of lower non-resource tax rates (a common use of resource revenue across countries (**?**) and within them (**?**)). As the author of a 2014 Guardian op-ed laments, massive increases in U.K. oil revenue in the 1970s and 1980s was used to fund "Thatcher's tax-cuts for the rich" (**?**). This is not to say that, had the U.K. instead saved the resource revenue in a SWF a Norwegian-sized fund would exist in the U.K. First, much of the UK's oil production happened earlier than Norway's, at a time when prices were lower (**?**). Additionally, Norway was blessed with larger field sizes, leading to lower extraction costs (**?**). Still, this comparison helps to shed some light on "what could have been" for the U.K.



(a) Norway (b) United Kingdom

Figure 1: Resource Funds & Production: Norway and the United Kingdom

Notes: The real (2014 $) value of Norway's Government Pension Fund–Global (GPFG) is given by the solid blue line (constructed from Norges Bank Investment Management (NBIM) annual reports 1998-2020 (**?**)). The dashed red lines represent the value of production of petroleum and natural gas (data collected from (**?**)). Values are real and expressed as billions of 2014 US$. As of 2015, the value of Norway's GPFG was $840 billion, or around 45% of total lifetime aggregate oil production. If the UK also had a wealth fund valued at the same percentage of lifetime oil production value, the fund (in 2015) would have been worth around $624 billion.

The British National Oil Company was privatized in the 1980s, whereas Norwegian state-owned oil companies retained majority stakes in most of the oil fields (**?**). Thanks to this

equity, the Norwegian government earned close to US$10 per barrel in revenue alone (**?**). But it was not until 1990 that the GPFG was founded, and high levels of state equity come with fiscal risks. Norway's oil revenue in the 1980s was predominantly spent as soon as it was earned. Much of the money went to social spending on healthcare and education, as well as improving physical infrastructure (**?**). But there was also windfall money used to prop up dying or non-competitive sectors which would later perish (**?**). The final years of the 1980s brought a severe drop in government spending with the collapse of oil prices. This led to an increase in bank failures and citizen bankruptcies (**?**).

Political will to turn non-renewable resources into wealth for future generations paved the road for Norway's fund to become what it is today. There is no question that the GPFG is a wealth fund world leader, but the fund was created decades after North Sea oil was first discovered. The UK missed an opportunity to start a wealth fund in the 80s and 90s. If the U.K. mimicked the type and structure of the Norwegian fund, how large would the U.K. fund be today? The aggregate value of all Norwegian oil production is approximately $1.9 trillion. For the UK, the amount is around $1.4 trillion (**?**). These amounts are both in 2014 US$—by taking their ratio and multiplying by the the current GPFG size, a similar U.K.fund would have a value around $624 billion today. There is still an opportunity for the U.K. to establish a resource fund; as of 2020, the Oil and Gas Authority estimates recoverable reserves between 10 billion and 20 billion barrels of oil equivalent under the British seas (**?**).

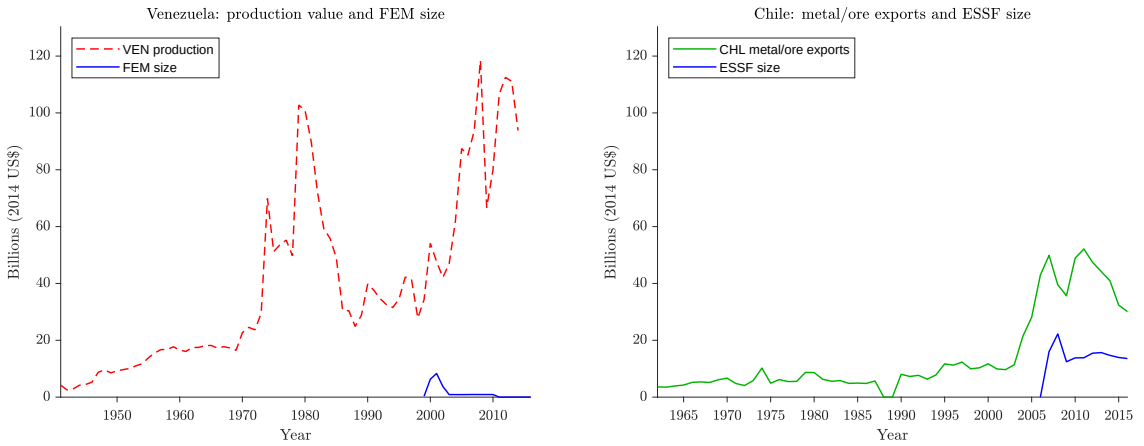
4.2 Chile and Venezuela: Governance matters

Chile holds the world's largest reserves of copper and is the largest copper exporter (**?**). In 1985, the Copper Stabilization Fund was established to smooth public spending in the face of volatile copper prices and subsequent revenues. The Economic and Social Stabilization Fund, ESSF, was created in 2007 replacing Chile's existing fund and absorbing its capital stock (**?**).

In a similar vein, Venezuela holds the largest proven oil reserves in the world (**?**). The

Macroeconomic Stabilization Fund, FEM (Fondo para la Estabilizacion Macroeconomica), was founded in 1998 to soften economic blows resulting from oil-price volatility, as much of the state's funding comes from oil revenues.

Both Latin-American countries are world leaders in valuable natural-resource stocks, but their stabilization-oriented funds have followed two distinct paths. Chile's ESSF is worth over US$8 billion as of 2021Q1 (**?**). Venezuela's FEM reached a peak value of over US$7 billion in 2001 only a few years after it was formed. However, by 2004, the fund's assets had dropped under US$1 billion, and today hover around US$3 million (**?**). Why was the Chilean fund so successful whereas the Venezuelan fund failed? We can glean some insights from Truman's SWF Scoreboard. In 2009, the Venezuelan fund received a score of 23/100, reflecting its poor governance structure, lack of accountability, and investing behaviors (**?**). The fund's rules were changed with each iteration of budgeting laws, making the FEM a more discretionary spending account, undermining its stated objectives (**?**). As of 2019, the FEM no longer receives any ratings.



(a) Venezuela (b) Chile

Figure 2: Resource Funds & Production: Venezuela and Chile

Notes: ESSF: Economic and Social Stabilization Fund; FEM: Fondo para la Estabilización Macroeconómica (Macroeconomic Stabilization Fund). The sizes of Venezuelan and Chilean funds are given in blue (**??**). The dashed red line indicates the value of Venezuelan production of petroleum and natural gas (**?**). The green line indicates the real value of Chilean ores and metals exports (**?**). All values are in 2014 US$.

In contrast, Chile's score using the same benchmark in 2009 was 70/100 and has risen

to 90/100 in 2019, placing it squarely in the top five rated funds worldwide **?**. The Chilean Ministry of Finance maintains easily accessible, publicly available information about the ESSF from asset management values to risk benchmarks. Despite the rise in rating, Chile's wealth fund has fallen in value from its peak of just under US$20 billion. The government has made no contributions to the fund since 2013 (**?**). It should be noted, however, that this is in line with laws passed when Chile's wealth funds were established setting contribution and withdrawal rules. Specifically, fiscal surpluses must be transferred to the ESSF the next year; this fund (the ESSF) works in tandem with a separate fund used for pension and welfare payments (**?**).

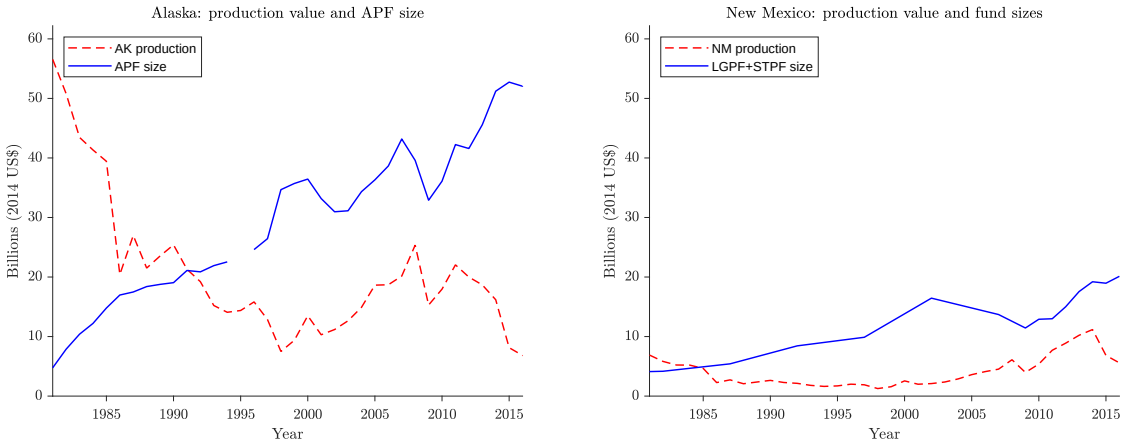
Venezuela's wealth fund was drawn down by what appear to be opportunistic changes to its structure over time. Chile's wealth fund has been playing by the same rules for 15 years and still exists. Maintenance of strong checks and balances between the state and the fund's assets, however, will guide withdrawals in line with the fund's objectives rather than pet-projects or personal gain.

4.3 Alaska and New Mexico: Similar goals, different methods

In the late 1960s the largest oil field in the United States was discovered in Prudhoe Bay, Alaska. In 1976, the Alaska Permanent Fund, APF, was created in the wake of competition for drilling rights on the state's land. The recently completed oil infrastructure, including the Trans-Alaska pipeline, prompted the state to save a portion of the annual oil revenues to benefit all generations of Alaskans though the APF (**?**).

New Mexico's State Investment Council (NMSIC) manages the state's seven permanent funds, the two largest of which are the Land Grant Permanent Fund, LGPF, and the Severance Tax Permanent Fund, STPF. The LGPF's founding predates the statehood of New Mexico and its funding comes from resource royalties and land leases. The primary goal of the LGPF is public school and university support (**?**). The STPF receives its funding from resource taxes, and the fund's objective is bond maintenance, with the state's general fund

receiving revenue beyond the bond requirements (**?**).



(a) Alaska (b) New Mexico

Figure 3: Resource Funds & Production: Alaska and New Mexico

Notes: APF: Alaskan Permanent Fund; LGPF: Land Grand Permanent Fund; STPF: Severance Tax Permanent Fund. The fund size for each state is given by the solid blue line (in real 2014 US$). Data on the APF is taken from (**?**). New Mexico fund sizes are taken from (**?**) with earlier data approximated from (**?**). The dashed red lines represent the value of oil production per year, in billions of 2014 US$ (**?**).

The NMSIC and APF score highly on each of the wealth fund benchmarks, earning no lower than 86/100 since 2009 and both score similarly within each category (**??**).

Alaska's APF disburses cash payments on principal earnings directly to its citizens, and has done so since 1982 through the establishment of the Permanent Fund Dividend, PFD (**?**). All residents receive the same amount, and in recent years the PFD's payments have accounted for up to 5% of per-capita annual income for Alaskans, even up to 10% for the state's indigenous populations (**?**). New Mexico's LGPF and STPF do not grant payouts to residents of the state, as opposed to the APF. The STPF is, however, estimated to lighten the average household's tax burden by around $1000 annually (**?**). Parents with children in New Mexican public schools benefit from the increased LGPF school funding. The eligible parents/guardians in similar Alaskan families with receive the additional PFD per child with no spending restrictions. Taken as a whole, the distribution in Alaska's program could be considered relatively more progressive, given that the New Mexico Fund likely offsets a portion of the state's income tax. Both are funds for transfers of generational wealth; Alaska

has a basic universal payment while the majority of New Mexico's funds are earmarked for education.

Residents in Alaska must apply for the dividend each year. New Mexico's funds do their work in the background—no filing process is required for benefits. For New Mexicans, even with the reduction in tax burden from the STPF, lack of explicit payout directly to citizens may affect attitudes toward the fund: Williams argues that residents failure to think of fund benefits as income leads to viewing the funds too conservatively (**?**). Such conservative views help the funds grow faster over time by avoiding disbursements, but can be detrimental due to oppositions in spending increases or reallocations that may be beneficial (**?**). For example, New Mexico's K-12 public schools rank lowest in the nation, despite the LGPF enhancing the state's expenditures on public schooling (**?**). Both funds score high in governance/accountability, but this metric does not capture how strongly fund recipients are attached to the benefits. It is probably easier to notice a smaller PFD check than a decrease in overall public school funding—"protect the people's full PFD" is in the first sentence on the Facebook campaign page of Alaska's current governor.

A small body of empirical work has investigated the socio-economic impacts of the Alaska Permanent Fund Dividend. The evidence to date has found that the annual payment of the PFD leads to: an increase in employment for men on the extensive margin but a decrease for employed women on the intensive margin (especially those with young children) (**?**), excess sensitivity in consumption from high income households (**?**), temporary decreases in financially motivated crime but increases in substance abuse (**?**), and benefits to children's health (**?**).

The continuously high benchmark scores achieved by the NMSIC and the APF reflect a degree of institutional quality sufficient for fund growth and longevity. Both states turned their stocks of non-renewable resources into robust long-term vehicles for investment in future generations. Though there are differences in how the funds have benefits respective state residents, both funds have arguably been successful in achieving inter-generational wealth

transfer and increasing contemporary private consumption.

5 Discussion

Natural-resource funds offer a variety of theoretical benefits including macroeconomic stabilization, intergenerational wealth transfer, and domestic investment. While the existing theoretical work makes a convincing case, empirical tests of the viability of SWFs are scarce. Some of this might reflect that the widespread use of resource funds is a relatively recent phenomenon. But identifying the effects of SWFs is not a simple exercise either. Here we review some of these econometric challenges and offer some possible remedies and suggestions for future research.

In an ideal setting, how would the effects of resource funds be identified? First, a large number (N) of units (e.g., countries or sub-regions like U.S. states or Canadian provinces) would exogenously discover an identical deposit of a valuable natural resource. Of this set, half would randomly be assigned to create, manage, and maintain a SWF (with a common target, such as macroeconomic stabilization). By randomly assigning SWFs, and assuming N is a sufficiently large number, a precise and unbiased estimate of the causal effect of resource funds can be identified by simply comparing average outcomes in the control group (resource-rich units not assigned to a fund) to those in the treatment group (resource-rich units assigned to a fund). In reality, however, resource-funds are not randomly assigned. Rather, their assignment is endogenous, and likely correlated with other observed (and unobserved) factors that influence possible outcomes of interest (such as the quality of political institutions or economic volatility and growth). This introduces omitted variable bias into regression analyses that can lead researchers to draw invalid conclusions.

There are two broad sources of endogeneity. As discussed by (**?**), establishing a meaningful SWF requires significant capital; some natural-resource endowments are large enough to establish a fund and others are not. This is problematic if outcomes of interest are en-

dogenous to the size of the natural-resource endowment. For example, suppose that large natural-resource endowments cause political corruption (as the existing research indicates), and that large endowments are also required to establish funds. Here, even restricting a sample to units endowed with natural resources, one might find that resource funds are associated with political corruption. But in this context, it would be wrong to conclude that funds cause the corruption. Rather, in this case large resource endowments cause both the establishment of funds and corruption.

Simply conditioning the effect of resource funds on resource production or resource dependence is not appropriate for two reasons. First, resource production and dependence are both endogenous variables (resource production is endogenous to institutional quality **?** and resource dependence is additionally endogenous to the size of GDP (**??**).[21] Second, the relationship between resource wealth and outcomes of interest might be non linear. As such, controlling for resource wealth in an OLS regression on the establishment of a resource fund would not be appropriate.

Ideally, the effects of resource funds can be estimated among a group of units (with and without funds) that have similar resource endowments. But here, small sample size becomes an issue. This point is highlighted in Table 2 which depicts the twenty largest producers of oil and gas per capita from 1932-2014[22]. Note that the most oil and gas rich countries (per capita) all have a sovereign wealth fund. In fact, among this list, only four countries do not currently have a fund: Venezuela, Canada, Iraq, and the United States (both the United States and Canada have sizeable state and provincial-level resource funds). Restricting an analyses to this set of countries serves the purpose of limiting unobserved

[21] In fact, what differentiates countries like Saudi Arabia, Russia, and the United States is not oil production, but rather, non-oil production. Whereas all three countries produce roughly similar quantities of oil (the United States currently produces slightly more oil than both other countries), the United States produces roughly nineteen trillion dollars worth of non-oil products. To the extent that weak institutional quality causes deteriorates non-resource sectors like manufacturing and services, variation in institutions causes variation in resource dependence, rather than the other way around.

[22] These data were collected from (**?**) and expressed as millions of U.S. dollars (2000 is the base year)., along with information about whether each country has currently established a SWF, and if so, the year of establishment. Countries are ranked from highest producers to lowest.

heterogeneity (all countries are major fossil fuel producers), but comes at the cost of a small sample. For example, using this restricted sample, one could compare contemporary outcomes in countries with SWFs to those without, but Iraq and Iran are arguably not valid controls for, say, Norway. One might try to exploit heterogeneity in the timing that SWFs were established, but note also that countries with more significant historical oil and gas production tend to have established their funds early. For example, the Kuwait Investment Authority was created in 1953, the Saudi Arabian Monetary Agency in 1952, and the Abu Dhabi Investment Authority in 1976. Given that both the establishment (and the timing of establishment) are correlated with historical resource production, identifying the effect of SWFs is challenging. This problem of small sample size is exacerbated when one considers the fact that not all funds are created with equal intent. Rather, some are designed as stabilization funds, other are designed for the purpose of intergenerational wealth transfer, or as domestic investment funds.

Table 2: Oil & Gas Production and the establishment of SWFs

Country	(Oil & Gas)/Pop	Year	SWF
Qatar	1.345	2005	Qatar Investment Authority
Kuwait	1.165	1953	Kuwait Investment Authority
UAE	0.843	1976	Abu Dhabi Investment Authority
Brunei	0.792	1983	Brunei Investment Agency
Saudi Arabia	0.406	1952	Saudi Arabian Monetary Agency
Norway	0.298	1990	Government Pension Fund-Global
Libya	0.277	1981	Libyan Investment Authority
Oman	0.242	1980	State General Reserve Fund
Trinidad and Tobago	0.183	2007	Heritage and Stabilization Fund
Bahrain	0.172	2006	Mumtalakat Holding Company
Equatorial Guinea	0.161	2006	Fund for Future
Gabon	0.157	1998	Fund for Future Generations
Venezuela -	-	-	
Canada	-	-	-
Iraq	-	-	-
Russia	0.073	2004	Reserve & National Welfare Funds
Turkmenistan	0.065	2008	Stabilization Fund
Iran	0.056	2010	National Development Fund
Algeria	0.054	2000	Revenue Regulation Fund
United States	-	-	-

Note: The value of oil and gas production per capita is taken from (**?**). Value of production is expressed in millions of U.S. dollars (year 2000) per capita and is summed for each country from 1932-2014.

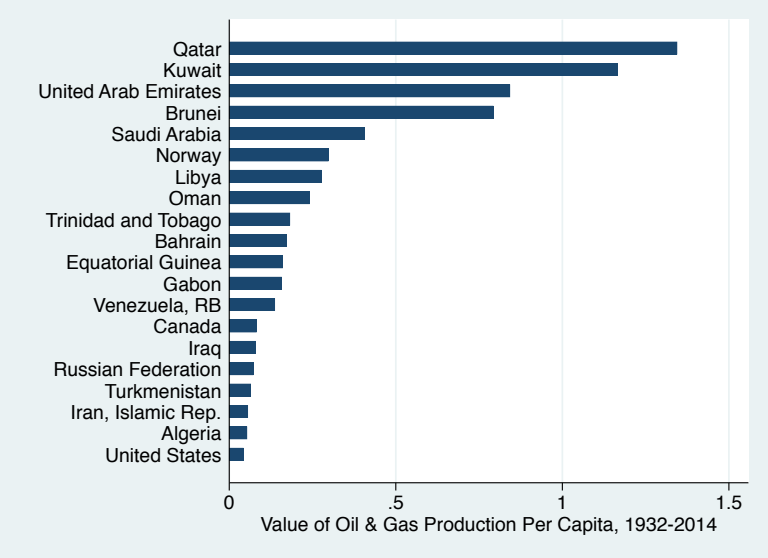


Figure 4: Oil & Gas Dependence

Note: The value of oil and gas production per capita is taken from (**?**). Value of production is expressed in millions of U.S. dollars (year 2000) per capita and is summed for each country from 1932-2014.

Conditional on being able to establish a fund, additional endogeneity is introduced by the fact that establishing a SWF is choice. Some governments choose to establish a fund, and other do not. A corrupt government might be less likely to establish a SWF as it could make rent seeking less profitable for public officials. It is also possible that governments establish stabilization funds in response to extraordinary macroeconomic volatility. As such, one might find that the establishment of SWFs is associated with reduced corruption and enhanced economic volatility!

As discussed in Section 3.4, some empirical research has made attempts to address these identification issues. One approach is to condition estimates on observables or proxies for unobservables. This includes adding controls for institutional quality indices and measures of resource income and wealth. Conditioning has the advantage of allowing these confounders to be time-varying (especially relevant for changes to resource income and the value of resource endowments). However, conditioning on observables cannot control for unobservable factors, may suffer from the problem of "bad controls," and require extrapolation outside the sample data. Institutional quality indices may be insufficient to control for the effect

of corrupt institutions. If establishment of wealth funds has a causal impact on corruption or rates of mineral extraction, then conditioning on these variables would amplify bias in estimating linear models. Finally, as discussed, the finite number of jurisdictions which have implemented wealth funds can make matching difficult, as they tend to be holders of large resource endowments.

Utilizing fixed effects (e.g. **?** **?**) can address the issue of time invariant unobservable characteristics, which could credibly address some aspects of institutional quality (e.g. intrinsic culture characteristics) and a jurisdiction's geologic resource base. Using an instrumental variables approach as in **?** would mitigate issues around time-varying unobservables, but performance depends on highly on instrument quality which is difficult to assure in practice. Synthetic control (e.g. **?**) and matching approaches might present a fruitful course of future empirical national-level investigations. Much like the resource-economic development literature has recently migrated toward sub-national analysis, there are likely unexploited opportunities to understand the fiscal outcomes of sub-national jurisdictions.

6 Conclusion

Our review examined what economists know and do not know about natural-resource based sovereign wealth funds. While we cannot address completely at this time our motivating question of whether we should set up a SWF for everything, we have identified several key points. For non-renewable resources, we know that in theory that establishing a SWF can be useful in many contexts over the long run, and with the best empirical estimates we see that these funds have proven to be helpful. We also find that management quality and institutions matter for SWF success. Funds are more successful when matched with good governance and strong political institutions. But we also know that SWF are not for every country or state government—some countries with either (a) strong domestic investment opportunities or (b) significant debt are better off doing something else with their resource

rents, at least in the short run. In these cases, capital-scarce markets receive high rents on capital investments and lower debt.

Given these pros and cons, note that only ten states in the US have so far created a natural-resource-based SWF. Is it still possible for some of these other forty states to start their own permanent fund now? In the case of Minnesota, **?** show that "yes" it is still possible to create a significant fund even though much of the State's iron ore mining industry is relatively small compared to 60 years ago. Under reasonable forward-looking assumptions, they estimate that enough minerals could still be extracted to create a permanent fund ranging between $3 to 5$ billion by 2050.

In the case of renewable resources like fisheries and forestry, we do see that long-term permanent funds have been established to help support conservation into the future, albeit wildlife, water, land, and environmental quality. A few permanent renewable resource funds do exist that generate a flow of income for conservation of land and habitat, such as the Wyoming Wildlife Fund, the Berkshire Environmental Endowment Fund, and the Massachusetts Environmental Trust (see for example **?**). Other renewable resource funds are revolving funds—money in, money out, such as the Conservation Fund with it is Working Forest Fund and the International Monetary Fund's Managing Natural Resource Wealth (MNRW) Topical Trust Fund (**?**).

From a theoretical perspective, two of the three main reasons for having a SWF from a non-renewable resource do not necessarily apply to renewable resources (see **?** and **?**). First, for permanent income, in theory there is no need to smooth a temporary windfall into permanent income, because the resource already generates a permanent income. Second, for the case of parking funds, there is not much need for this type of fund in developing countries, because renewable resources do not generate short-sharp windfalls like an oil discovery. However for the third reason—volatility, a case can be made for a SWF based on precautionary savings from a volatile renewable commodity. A "stabilization fund" that is built up when prices are high, drawn down when prices are low, would make sense if the

commodity price is mean reverting. But one of the main justifications for non-renewable stabilization funds is to avoid other industries temporarily contracting, and so losing technology from learning-by-doing. This matters less for renewable resources because they are a permanent part of the industrial landscape, e.g., Australia's car industry disappeared when iron ore prices boomed in 2010-2012, which would be a problem if we were about to run out of iron ore, and had to start relying on cars again. This would be less of a problem if the car industry disappeared because of a spike in wheat prices, because the wheat industry is not going anywhere.

Finally, we believe that wildlife/water/environmental funds still make sense, but the justification comes from internalizing externalities. This applies to all countries, regardless of whether they have renewable or non-renewable resources. One argument is that environmental externalities are greatest in countries that have large renewable resource endowments (e.g., Brazil farming vs rainforest), such that renewable-resource-rich countries should be particularly motivated to set up environmental funds to offset them. Another justification could be that some resources that we think are renewable may not be after all, due to over-extraction and climate change. Countries could set up SWFs because they know the resource is going to run out, with the justification being the same as for non-renewable resources.

For empirical estimation on the power of SWF, we see that future research will be presented with continued and serious identification challenges - until a broader set of countries (or units) implement wealth funds that allow for proper identification. If half the cities in the U.S. established funds, for example, identifying the effects of having a city fund would be much more straightforward.

7 Appendix I

The theory in Section 2 is based on an optimisation problem where a social planner (the government) receives a temporary oil windfall of price $P(t)$ and quantity $O(t)$, and must decide whether to use the proceeds for consumption $C(t)$, investment $I(t)$ in domestic capital $K(t)$, or saving in foreign assets $F(t)$ (or repaying foreign debt if $F(t) < 0$). Following Wills (2018) the planner must maximize the continuous time value function $J(\cdot)$[23]:

$$
\begin{aligned}
J(F, K, P, t) &= \max_{C(t)} \left[\int_t^{\infty} U(C(\tau)) e^{-\rho(\tau - t)} d\tau \right] \\
&\quad s.t. \\
S(t) &= F(t) + K(t) - S^* \\
dF(t) &= \left(r\left(F(t)\right) F(t) + P(t)O(t) + Y\left(K(t)\right) - C(t) - I(t) \right) dt \\
dK(t) &= (I(t) - \delta K(t)) dt \\
dP(t) &= \alpha P(t) dt + \sigma P(t) dZ(t)
\end{aligned}
$$

where $U(\cdot)$ is the utility function, $S(t)$ is the deviation of total assets from their steady state S^*, ρ is the rate of time preference, $r(F(t))$ is the interest rate faced by the planner which may depend on the level of assets/debt, $Y\left(K(t)\right)$ is the level of output which depends on domestic capital, δ is the depreciation rate on domestic capital, and oil prices $P(t)$ follow a geometric brownian motion with drift α, volatility σ and Wiener process $Z(t)$.

Solving this model assuming constant absolute risk aversion yields the two first-order conditions for consumption and total assets[24]:

[23] For a similar version in discrete time see Venables and Wills (2016)

[24] For details see Wills (2018)

$$\frac{1}{dt}E[dC(t)] = (r - \rho - p\,(F(t))) + \frac{1}{2}aP(t)^2C_P(t)^2\sigma^2 \quad (1)$$

$$\frac{1}{dt}dS(t) = rS(t) + P(t)O(t) - C(t) + C^* \quad (2)$$

where r is the global riskless rate of interest, $p\,(F(t))$ is the risk premium on interest rates ($p'_F > 0$), $a > 0$ is the coefficient of absolute risk aversion (and prudence), $C_P(t) \equiv \partial C(t)/\partial P(t)$ is the marginal propensity to consume from a change in the oil price, and C^* is the pre-windfall steady-state level of consumption.

Parameterising these two first-order conditions yields many of the results in Section 2. Section 2.1 describes how governments in developed countries should save their oil windfall in a Sovereign Wealth Fund so that consumption is stabilized at the permanent income level. This can be seen when the world rate of interest equals the discount rate, $r = \rho$, there is no risk-premium on borrowing $p\,(F(t)) = 0$, and oil prices are deterministic $\sigma = 0$, so that $dC(t)/dt = 0$.

Section 2.2 outlines how developing countries, which face capital-scarcity due to a risk premium on borrowing, should direct some of the windfall to accumulating domestic capital and repaying debt, so that consumption gradually rises to its steady state. This can be seen when $r = \rho$, $\sigma = 0$ but foreign assets $F(t) < 0$, so that there is a risk premium on borrowing $p\,(F(t)) < 0$, and $dC(t)/dt > 0$.

Section 2.4 states that all countries should save more in the interests of precautionary savings. This is seen by allowing oil prices to be volatile, $\sigma > 0$, which causes the optimal path of consumption to rise, $dC(t)/dt > 0$. Consumption is therefore lower today, which allows assets to be accumulated to fund higher consumption in the future.