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Economics of Wine Import Duty and Excise Tax Drawbacks

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The wine drawback program allows a refund of 99% of import duties and excise taxes on wine for which the importer has matching exports of commercially "interchangeable" wine. Because per-unit import duty and excise tax rates are substantial compared to the price of bulk wine, use of the program is high for bulk wine imports, which compete with wine from low-price Central Valley grapes. Bulk wine exports dominated imports until 2009 and the program stimulated import growth. Now, with imports and exports roughly in balance, the program stimulates both exports and imports—leaving net trade in bulk wine roughly in balance.

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Drawbacks go back to the Second Act of Congress, July 4, 1789, which allowed a 99% drawback on duties paid on merchandise imported into the United States if the merchandise was exported within a year. Rules covering drawbacks differ by industry and have changed many times in the past 220 years, but the guiding purpose remains to facilitate import of items that will be subsequently re-exported in order to encourage domestic value added.

Current laws governing drawbacks are found in 19 USC 1313 and are administered by U.S. Customs and Border Protection (CBP). Against this long history, drawbacks for wine have only been significant for just over a decade and have grown substantially over that period.

For about a decade, the United States has offered a refund of import duties and federal excise taxes on imports of non-sparkling wine of 14% alcohol or less whenever firms match imports with exports of wine legally defined as "interchangeable." U.S. regulations define interchangeable exports of wine for drawback eligibility as those of the same color and within 50% of the price of the imports (and of 14% alcohol or less and non-sparkling wine). A firm has up to three years to match imports with subsequent exports and claim the drawback.

The U.S. Bureau of Customs and Border Protection administers the drawback and enforces the rules of the program, mainly through audits. All discussion of wine and wine markets in this brief article refers to the broad category of wine to which the drawback applies. Wine exported to Canada or Mexico is not eligible to use as a match for imports in applying for drawbacks.

Imports, Exports, Duties and Taxes

Import duty schedules are complex. Duty rates differ for wine by specific product and country of origin, and have changed over time, especially with the implementation of free trade agreements (FTAs). For wine, the important FTAs are those applying to Australia and Chile.

Table 1 provides a summary of wine import duties and excise taxes. The total of import duty and excise tax reaches more than $0.42 per liter for large container sizes from non-free trade sources, with the excise tax larger than the import duty in all cases. These import duties compare to import prices that average more than $4.00 per liter for imports in containers of two liters or less (typically bottles) and less than $1.00 per liter for the large-container imports (most of which arrive in 1,000-liter bladders, not in consumer-ready packages).

For bottled wine imports, the duty and excise tax together account for about 10% or less of the import price. However, for bulk wine imports, the duty rate and excise tax eligible for drawbacks are often close

Table 1. Excise Taxes and Import Duty Rates

	Two liters of less[1]	Over four liters (MFN)	Over four liters from Chile or Australia[2]
	-----(cents/liter)----		
Import duty rate	6.3	14.0	4.8
Excise tax	28.27	28.27	28.27
Total	34.57	42.27	33.07

Source: U.S. International Trade Commission. 2011. "Interactive Tariff and Trade DataWeb." http://dataweb.usitc.gov/

[1] Very little wine is traded in the two to four liter size containers.

[2] Import duty rates have been declining gradually for Australia and Chile in accordance with the Free Trade Agreements. Here we report and use the 2010 rates.

to 50% of the import price—clearly large enough to affect trade.

Since an import quantity must be matched with an interchangeable export quantity in order to receive the drawback, table 2 compares U.S. imports and exports of wine by container size over the eight years from 2004 through 2011. For both imports and exports, the quantity shipped in smaller containers has declined slowly while the quantity imported and exported in bulk containers has grown rapidly.

As drawbacks have become a more prominent feature in the industry, bulk wine imports and exports both expanded. Moreover, bulk exports exceeded bulk imports by a large margin as recently as 2008, but jumps in bulk imports mean that they exceeded exports in 2009 and again in 2011.

Although we compare imports and exports year-by-year in table 2, we emphasize that drawbacks for an import shipment may be matched against exports that occur within three years. This means that a firm may qualify for the drawback so long as it ships enough eligible exports within three years of the import date.

No export data are available by color, so we are not able to compare imports and exports by that interchangeability criterion. Since there are large differences between the prices of wine by container size, we use the size category as a proxy for price in determining whether imports and exports might be considered interchangeable.

Table 3 uses data on imports by container size and source, together with data on import duty rates and excise tax rates, to calculate the approximate value of duties and taxes due from 2005 to 2010. Total duty and excise taxes over this period ranged from about $207 million in 2005 to a high of $293 million in 2009. Most of the payments are for excise taxes because of the high tax rate and most are associated with bottled imports because bottle imports are still more than three times the volume of bulk imports.

Drawbacks and Implications for Markets

There are two reasons that drawback applications are likely to be relatively small for bottled imports. First, the import quantity eligible for a drawback is limited by the quantity of matching exports and, given the price-range requirement, exports in containers of two liters or less are likely those that could be used to qualify imports in this container size for the drawback. Also

Table 2. Volume of U.S. Wine Imports and Exports, Excluding Exports to Canada and Mexico, by Container Size

	Exports				Imports			
	Container size				Container size			
	Two liters or less	Over two liters	Total sum	Share of exports in large containers	Two liters or less	Over four liters	Total sum	Share of imports in large containers
Year	----------(million liters)----------			(%)	----------(million liters)----------			(%)
2004	243.3	47.1	290.4	16.2	549.1	20.1	569.2	3.5
2005	160.2	82.9	243.1	34.1	593.7	39.6	633.3	6.3
2006	163.9	122.9	286.7	42.8	607.8	84.2	692.0	12.2
2007	175.1	150.1	325.3	46.2	659.9	92.0	751.9	12.2
2008	175.4	178.8	354.3	50.5	614.7	111.6	726.3	15.4
2009	143.7	157.5	301.1	52.3	604.6	218.1	822.7	26.5
2010	142.9	182.5	325.3	56.1	593.3	168.1	761.4	22.1
2011	144.8	174.6	319.4	54.7	672.4	215.6	888.0	24.3

Source: U.S. International Trade Commission. 2011. "Interactive Tariff and Trade DataWeb." http://dataweb.usitc.gov/

Table 3. Approximate Excise Tax and Import Duties Levied on Wine Imports, 2005–2010

	Two liters or less			Over four liters			
	Excise taxes	Import duties	Sum	Excise taxes	Import duties	Sum	Total
Year	($U.S. millions)						
2005	157.1	35.0	192.2	11.2	3.4	14.6	206.8
2006	170.1	37.9	208.0	23.8	7.5	31.3	239.3
2007	174.3	38.8	213.2	26.0	10.6	36.6	249.8
2008	186.9	41.6	228.5	31.5	12.7	44.2	272.7
2009	176.4	39.3	215.7	61.7	15.7	77.4	293.1
2010	173.4	38.6	212.0	47.5	12.7	60.2	272.2

Sources: U.S. International Trade Commission. 2011. "Interactive Tariff and Trade DataWeb." http://dataweb.usitc.gov
U.S. Customs and Border Protection, Department of Commerce. Special data request, 2011.

Note: Approximate excise tax and import duty values obtained by multiplying import quantities of wine in particular container sizes and countries of origin with excise tax rate of $0.2827/liter and relevant import duty rates in Table 1.

as shown in table 2, exports of bottled wine have remained less than one-third the volume of imports for this category.

Second, since the duty and excise tax rates are set per liter, there is much less competitive pressure to assure that bottled wine imports qualify for a drawback. The drawback is usually worth less than 10% of the import value for bottled wine. Two further complications are: First, importers of bottled wine may not be closely associated with the exports of U.S. wine and so do not have an easy way to qualify for the drawback. Second, bottled wine is often imported in relatively small lots (by volume) and so the transaction cost for qualifying for the drawback may be large relative to the benefit.

For bulk wine, these considerations are reversed. Export volumes were larger than import volumes until 2008; and in the last three years these volumes have been roughly in balance. Second, the potential drawback is large compared to the import price, so a firm that takes advantage of the drawback would have a significant net price advantage relative to the competition. Finally, some large U.S. wineries have significant roles in importing wine and producing and exporting U.S. wine.

Table 4 displays U.S. Customs data on drawbacks by container size and year of the drawback (not year of the import). Drawbacks on bottled wine have remained in the range of about 56 to 86 million liters, with no evident trend since 2005. Drawback volume has remained between 10% and 15% of import volume, and less than half of export volume, of bottled wine over the seven-year period for which data are available.

At the same time, drawbacks on bulk wine have grown from about 13 million liters to 121 million liters as imports and exports of bulk wine have both grown. Drawbacks have been claimed on about two-thirds or more of the volume of imports.

The implications of wine drawbacks for wine and grape markets in California follow from their effects on providing incentives for international trade. Most of the effects are in the bulk wine category and on the Central Valley grapes that provide the raw material for this wine.

During the period when exports already exceeded imports by a wide margin, the drawback acted as a kind of import subsidy, reducing the net price that buyers would have otherwise paid. In that situation, California wine and grape prices were lower than without the program. But, for the bottled wine category and in any period when imports would have already exceeded exports with no drawback, the program acts as a kind of export subsidy and the effects on California wine and grape

Table 4. Drawbacks by Import Container Size

	Container Size		
	Two liters or less	Over four liters	Sum
Year[1]	(million liters)		
2005	69.5	13.2	83.1
2006	78.2	43.6	122.5
2007	86.2	77.6	165.3
2008	55.6	68.3	124.5
2009	80.3	96.0	178.7
2010	66.0	121.4	188.1

Source: U.S. Customs and Border Protection, Department of Commerce. Special data request, 2011.
[1] Year in which drawback was claimed, not year of importation.

Bulk wine imports and exports have both expanded since drawbacks have become a more prominent feature in the wine industry.

prices are positive. In this case, imports would use drawback funds to stimulate the needed exports in order to allow imports to qualify for the drawback.

Under recent conditions, when imports and exports of bulk wine are roughly in balance, the drawback stimulates imports and exports by roughly the same degree and the effects on California wine and grape prices are offsetting, leaving only a small net effect.

Application of a simple simulation model shows how the effect of the drawback program for wine imports and exports, U.S. wine production and price, and U.S. grape production price depends on the pre-existing balance between import and export quantities.

How much drawbacks affect market prices and quantities depends on import and export shares, and the relevant supply and demand elasticities for wine and wine grapes—in other words, the responsiveness of wine quantity sold to price and of grape production to expected price. For example, our illustrative simulations find that during the period when exports exceeded imports, the bulk wine drawbacks probably suppressed California Central Valley wine grape prices by a few percent and, consequently, discouraged expansion of wine grape production.

The same simulation model shows that under the current situation in 2012, with imports at or exceeding exports, the program may stimulate slightly higher grape prices and production because drawbacks effectively stimulate wine exports. These aggregate implications mask benefits and costs to some firms or farms that are best suited to exports or compete most directly with imports.

Firms that produce and trade wine, and already export and import significant quantities, find the drawback program easy to implement. Firms that are small or operate solely in the domestic market, or are only importers or only exporters, must establish new business collaborations to access the drawback program.

Conclusions

Drawbacks are one of the oldest features of U.S. international trade policy, but are new to the wine industry. The drawback program was one stimulant of the rapid increase in bulk wine imports over the past decade and probably suppressed grape prices in the California Central Valley in the early to middle years of the past decade.

Currently, with imports at or exceeding exports, the drawback does as much to stimulate exports as imports and thus has, at most, small impacts on the relevant wine and grape markets in aggregate. Nonetheless, data on drawbacks are difficult to obtain and much more in-depth empirical research is needed to fully understand the operation of the program and its implications.

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How Do Workers Choose Referrals?

Lori Beaman and Jeremy Magruder

Job referrals are an important way that people find work across the globe. We use an experiment in Kolkata, India to ask whether people can identify highly skilled referrals, and when they are willing to do so (instead of referring a closer, but less skilled friend).

Globally, a large fraction of workers are hired through job references. An extensive literature, both in sociology and in economics, has documented the importance of social connections as a means of job search. For example, 30-60% of jobs in the United States are found through referrals. In Kolkata, India we find that 45% of our sample has found a job for a friend. A large and growing empirical literature in economics has more recently utilized a variety of quasi-experimental variations in the size or quality of job networks to confirm what survey data has shown: Job networks are empirically important.

While it is clear that job networks matter, we know much less about how they work and what the consequences of the use of informal social connections in the hiring process are to either firms or unemployed job seekers. In fact, while we have substantial evidence that job referrals are important in labor markets, we have much less evidence on even very basic questions about how they work, such as whether the use of referral systems results in good hires.

Theory has suggested two reasons to suspect that networked hires may be high ability: first, high-ability workers may associate primarily with other high-ability people, so that their referrals are mechanically high quality. Second, if networks are heterogeneous, then employees may be willing and able to screen on their employer's behalf. That is, if they know which of their friends represent a particularly good fit for a job opening, they may be willing to use that information and make a referral.

In a recent paper forthcoming in the *American Economic Review*, we test whether employees have useful information about their network members, and under what conditions they are willing to use that information. In our view, both the capacity and willingness of employees to screen on their employer's behalf can be questioned.

Social networks are formed for many reasons, at least some of which are unrelated to a person's potential as an employee for a specific job. Moreover, in order for employees to be useful in choosing which of their friends would make the best employee, it must be the case that whatever incentive they have to screen on the part of the employer can overcome whatever incentives they have to use that job opportunity in a different way.

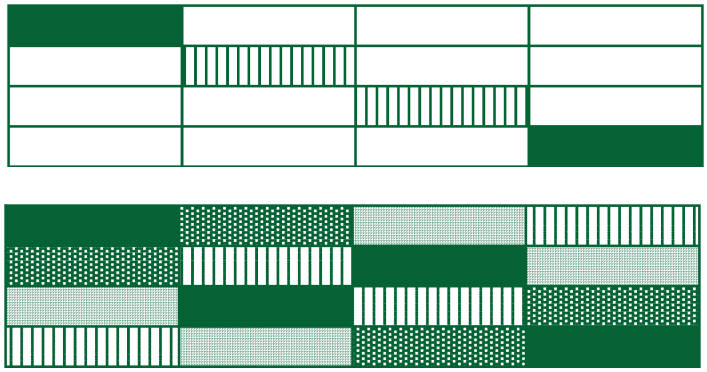
For example, in much of the literature on networks in developing countries, the role of networks to insure against risky events would suggest that people may make claims on the next good opportunity—like a job opening—that their friends learn of, and offer in exchange for a promise of sharing the next good opportunity that they learn of. This possibility would mean that new job referrals go to people who have the strongest claim to the next good opportunity rather than to the person who would be best at the job. Moreover, it is surely the case that altruism plays an important role in social networks, giving incentives to refer the network member one cares about the most rather than the friend who you believe to be the best worker or best match for that job.

Participants in the study, regardless of ability level, were about 50% more likely to bring in a coworker, and 50% less likely to bring in a relative, when they were given performance pay

We examine this tradeoff using a laboratory experiment in the field in peri-urban Kolkata, India. The idea behind our experiment is that once a person enters our laboratory, completes a task, and is paid for it, we have essentially given him a casual day-job. We can therefore allow our employee to make referrals into our laboratory, randomize his incentive to find a high quality worker, and observe actual referral choices.

This controlled framework creates several advantages: first, while the measurement of worker ability takes place within a laboratory environment, the actual behavior which we are measuring takes place when the worker goes

Figure 1. Sample Cognitive Task



home and determines which of his friends to refer. Thus, we are using the lab to measure an unmonitored behavior. Second, it allows us full control of the incentive contract. We know precisely what incentives our employees face to make a strong referral.

The set up of our experiment is as follows: Original Participants (OPs) were invited to perform two hours of work in our lab, for which they were guaranteed 135 rupees in payment. To ensure a sample of OPs who were representative of labor market participants, we recruited OPs at every third household in neighborhoods surrounding our lab; this resulted in a sample of OPs who were young, active labor-market participants, with an average age of 31 and a 96% employment rate.

Once these OPs arrived in the lab, they completed a survey and then-were asked to complete a task which emphasized cognitive skill. A minority of OPs were also assigned to a task which emphasized pure effort rather than cognitive ability, specifically the task of filling plastic baggies with precisely 20 peanuts each. As only a minority of OPs were assigned to this treatment, we restricted our analysis to the cognitive treatment.

More specifically, they were asked to help arrange a set of colored swatches in a square according to several sets of logical rules in order to help design quilts. For example, one set of rules gave OPs 16 swatches, four each of four different colors, and asked them to arrange the swatches so that no more than one of each color was in each row and each column.

A slightly more difficult puzzle is depicted in figure 1. Once again, OPs were asked to place one of each color in each row and each column; however, now they were also required to keep the diagonal cells fixed as in the top panel of figure 1. A sample solution is in the bottom panel. For each of these puzzles, our supervisor noted whether the OP reached the correct solution, how long it took the OP to solve the puzzle, and how many times the OP thought he had reached a correct solution when he was in fact incorrect.

Upon completion of the task, OPs were asked to identify a friend who "would be good at the task they just completed," and were offered a finder's fee for bringing in such a friend. The exact terms of the finder's fee contract were randomly assigned to OPs. A random selection of OPs were offered fixed finder's fees, which will pay the same amount regardless of their referral's performance on the task, while others were offered performance incentives, where the OP's pay may be indexed to the referral's performance. In both cases, referrals themselves were paid a fixed 135 rupees, regardless of their performance.

The experiment was completed when the OPs returned with their referrals. At that time, OPs and referrals were informed that they would in fact be paid the maximum payment possible under their contract, so that when referrals completed the task no one (neither the OP nor the referral) had a direct incentive to exert differential effort depending on their treatment status.

The motivation for this change in contracting terms was that we were particularly concerned that if OPs shared their finder's fees with referrals, then referrals in performance treatments may have additional incentives to exert effort. This concern, which seemed of first order importance in the experimental design, seemed to have little practical effect as very few of our participants—OPs or referrals—reported any intention of sharing their payments with each other.

There were four necessary conditions for performance incentives to induce OPs to change the person they chose as a referral: first, they had to face tradeoffs between the person who they would most like to refer for social reasons (e.g., altruism or because of claims on the next good opportunity) and the one who they believed to be the highest ability. Second, OPs must have had some information as to their friends' abilities, so that the performance incentives were more valuable if they refered a friend who they believed to be higher ability. Third, social incentives could not be too large, so that they overwhelmed the expected return (from us) to referring a socially suboptimal but high-ability friend. Finally, networks needed to be heterogeneous: if all of an OP's friends were the same ability, then the OP would not change his referral choice regardless of incentives.

OPs with different levels of information may have also responded differentially to treatment in their decisions to return with a referral, and we present evidence that high-ability OPs were

more likely to make a referral when faced with performance incentives. This was simultaneously a potentially useful result for employers, behavior consistent with high-ability OPs having better information, and a potential attrition problem for the analysis of the model's other predictions.

We solved this problem by using a Heckman selection correction for the main analysis, which can control for systematic attrition of this type, provided one can identify a random source of variation which affects attrition but not performance on the puzzles. In our case, we used the fact that rain in Kolkata can be quite severe, which occurs at random on a particular day of the year. A day of rainfall made travelling to our laboratory less appealing, yet should not have the ability to impact a referral's ability to solve logic puzzles.

We focused on two types of analyses. First, did OPs change the types of relationships that they brought into the lab? If OPs responded to performance pay by choosing more socially distant referrals, we interpreted that as evidence that they were trading off social incentives for our cash incentives. Second, did OPs succeed in bringing in higher ability referrals when they received performance pay? For all analysis, we looked for differential effects for higher ability OPs: ability has been identified in many peer effects and networks studies as an important dimension of heterogeneity.

Our results indicate that all OPs respond to network incentives by changing the types of relationships that they bring in. OPs, regardless of ability level, were about 50% more likely to bring in a coworker, and 50% less likely to bring in a relative, when they were given performance pay (both results are statistically significant).

We interpret this result as evidence that all OPs respond to performance incentives by bringing in more socially distant network members. This interpretation is supported by data we collected on gifts and loans: relatives play a dominant role in gift and loan networks, while coworkers are only marginally involved in either gifts or loans.

Interestingly, despite the fact that our OPs were all, on average, responding to performance incentives by bringing in more socially distant referrals, they did not, on average, bring in higher ability referrals when they were given performance incentives. This result, however, hides some important heterogeneity: high-ability OPs respond to performance incentives by bringing in significantly higher ability referrals.

This result tells us that high ability OPs, at least, meet all four of our necessary conditions: they had information about the skills of their network members, they faced social tradeoffs so that they would rather not use that information, those social tradeoffs were not overwhelming in magnitude, and their networks were heterogeneous in ability.

We also document that at least one reason that we did not see these effects for low-ability OPs is that low-ability OPs did not appear to have very much information about their referrals' ability levels. We asked all of our OPs how well they expected their referrals to perform, and while high-ability OPs' predictions were strongly and significantly correlated with their referrals' performance, there was no relationship between the predictions made by low-ability OPs and how their referrals actually performed.

This study offers a first look inside how individuals make the choice of who to refer for new job opportunities, and test of screening models as a motivation for referrals. We were able to both confirm the capacity to screen (at least among high-ability people) and the presence of social tradeoffs which could limit successful screening. In future work, we hope to explore more deeply exactly how a network "works" in terms of determining how it allocates new opportunities and the consequences of that allocation.

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For additional information, the authors recommend:

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Faculty Profile: Jeremy Magruder

Jeremy Magruder
Assistant Professor -
UC Berkeley -

Jeremy Magruder joined the faculty of the Department of Agricultural and Resource Economics at UC Berkeley as an assistant professor in July 2007. Jeremy earned his Ph.D., M. Phil., and M.A. in Economics at Yale University, after completing his B.A. in Economics at Michigan State.

Jeremy's dissertation, "Unemployment, AIDS, and Schooling Decisions in South Africa," included three essays on the economic challenges facing South Africa. His job market paper, "Intergenerational Networks, Unemployment, and Persistent Inequality," which was published in the *American Economic Journal (AEJ): Applied Economics* in 2010, used panel data on young adults in Cape Town. He asked whether parents were important network connections for their children in South Africa—a context where jobs were very scarce.

Using shocks to labor demand in parents' industries, he found evidence that fathers were very useful in helping their sons find work, with father connections explaining up to one-third of all jobs found by their sons. Daughters, however, did not benefit similarly from their mothers.

Other work in his dissertation included the paper, "Marital Shopping and Epidemic AIDS," which was published in *Demography* in 2011. This evaluated the performance of a variety of behavioral and epidemiological models of the HIV epidemic under two criteria: biological plausibility and ability to explain a strong pattern in ages of infection observed in South Africa—where older women (and older men, to a lesser extent) appeared to be insulated from HIV infection.

He found that many of the behaviors emphasized in the policy and academic discourse struggled to predict this second criteria. In contrast, a simple model of serially monogamous dating-and-marriage both generated very high levels of prevalence and suggested that risk of infection at different ages should closely resemble the infection patterns in South Africa.

Since joining the faculty at UC Berkeley, Jeremy has focused the majority of his research on understanding the barriers to employment in developing countries. In addition to the role of social networks detailed in this issue of *ARE Update* and his dissertation, another series of papers looks at the role of labor regulations on employment.

One paper, "High Unemployment Yet Few Small Firms: The Role of Centralized Bargaining in South Africa," which is forthcoming in the July 2012 *AEJ: Applied Economics,* focuses on centralized bargaining in South Africa. According to centralized bargaining regulations, unions and firms can choose to extend the labor standards that they agree upon to workers and firms who are not unionized. This particular regulation has often been blamed for South Africa's anemic small firms sector, as small firm owners claim that large firms agree to higher labor standards than they otherwise would to drive out competition from small firms who wouldn't ordinarily have to pay union wages.

Utilizing variation in the geographic coverage of different agreements in different industries at different times, Jeremy has found strong evidence that these agreements were raising wages and reducing employment when present. Effects on small firms were particularly large, suggesting that the complaints of small firm owners may have been relevant. Ultimately, he estimated that these agreements could increase unemployment by about a percentage point—a large effect.

Jeremy lives in Oakland and loves the amenities of the Bay Area, including proximity to great hiking, restaurants, and the wine country. He has even found the high-quality restaurants nearby to be academically productive: in a recent paper with colleague Michael Anderson (forthcoming in the *Economic Journal*), Jeremy explored the effects of Yelp.com ratings on the presence of available tables in San Francisco.

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California Lettuce Industry Threatened by Imported Pathogen

Christine Carroll, Colin A. Carter, and Krishna Subbarao

The fungus *Verticillium dahliae*, which causes the disease Verticillium wilt, is an increasing problem for the California lettuce industry in Monterey and Santa Cruz counties. This paper discusses the introduction of the fungal pathogen to lettuce, policy options to prevent the disease, and ongoing research.

California growers planted 209,500 acres of lettuce in 2010. The value of California's lettuce crop, which represents the majority of United States' lettuce production, was over $1.6 billion. A large portion of California lettuce comes from Santa Cruz and Monterey counties.

In 1995, Verticillium wilt, a disease caused by the fungus *Verticillium dahliae*, appeared suddenly and unexpectedly in lettuce in Watsonville, Santa Cruz County. Lettuce was previously thought to be immune to the disease, which affects hundreds of other plant species. In the past fifteen years, the number of lettuce fields affected has increased dramatically, reaching more than 175 by 2010, and amounting to 3,952 acres. More than 50% of the newly contaminated fields were reported in 2009 or 2010, indicating that the problem has spread more rapidly in recent years. Lettuce growers and handlers in Monterey and Santa Cruz counties are extremely concerned about Verticillium wilt.

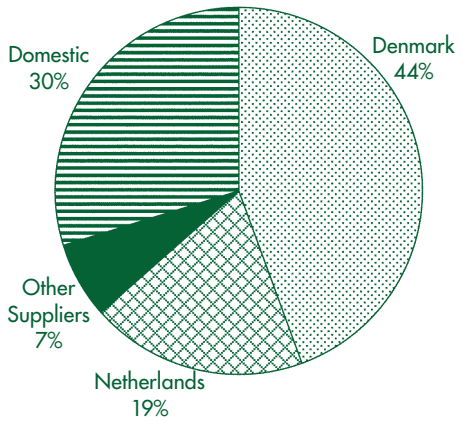
Due to the agronomics of crop rotation, lettuce production is closely associated with the production of strawberries, spinach, and broccoli, all of which ranked in the top ten in value of production in Monterey County in 2010. Spinach, in particular, is important because it is believed that the pathway for the introduction of *V. dahliae* into lettuce is spinach seeds. As shown in figure 1, approximately 30% of spinach seeds are grown domestically in the Pacific Northwest; the remainder are imported, primarily from Denmark and the Netherlands

Figure 2 shows the quantity of spinach seed imported by the United States. The recent increase in spinach production in California and the increase in V. *dahliae* in lettuce follow similar trends. Growers harvest spinach long before symptoms associated with the disease appear, but the Verticillium pathogen introduced from spinach seed remains in the soil. The fungus survives in the soil for up to ten years by producing black survival structures called microsclerotia.

During subsequent crop rotations, lettuce can be infected. Beyond a certain threshold of *V. dahliae* pathogen levels in the field (>150 microsclerotia per gram of soil), lettuce crops can be completely destroyed. Strawberries are also susceptible to this type of wilt. Broccoli, however, is immune and planting it can actually reduce the levels of *V. dahliae* in the soil.

The purpose of this paper is to discuss the economic causes of Verticillium wilt, evaluate the policy options to control the disease, and outline future research necessary to solve this problem. Because spinach seed is imported, international trade is a cause of this disease. Treatment options for Verticillium wilt include: early harvest, broadcast or bed fumigation, crop rotation to broccoli, resistant varieties of lettuce, and seed testing and quarantine. Consideration of the economic and

Figure 1. Origin of Spinach Seeds Planted in the United States in 2010

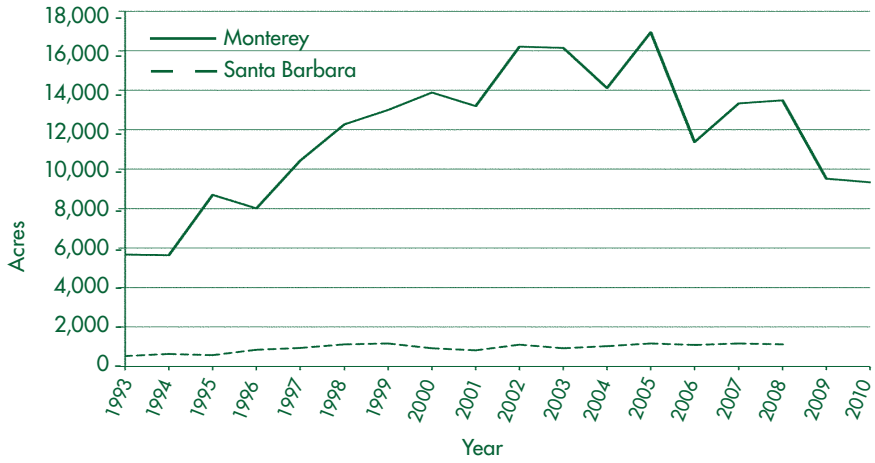


Source: Global Agricultural Trade System (GATS), USDA FAS. www.fas.usda.gov/gats/

Figure 2. Spinach Seed Imported by the United States

Source: Global Agricultural Trade System (GATS), USDA FAS. www.fas.usda.gov/gats/

Figure 3. Acres of Spinach Grown in Monterey and Santa Barbara Counties from 1993



Source: Monterey and Santa Barbara County Agricultural Commissioners Crop Reports: 1993–2010. www.ag.co.monterey.ca.us/ and www.countyofsb.org/agcomm/

practical feasibility of these different options should guide policy decisions.

Cause

Verticillium wilt is a disease caused by an invasive species. Agriculture has long been subject to significant damage from invasive species. As international trade has increased, the rate of pathogen introductions has also increased. Emerging infectious diseases (EIDs) caused by fungi threaten food security. Some estimates suggest the cost of lost crops due to non-indigenous plant pathogens in the United States is $21 billion per year.

Economics is an important tool for invasive species research because human behavior and economic activities affect invasions. Purposefully or inadvertently, economic activity, such as transport of fungal-infected tradable goods and food, transfers alien species to new locations.

In the case of Verticillium wilt, spinach seeds entering the lettuce production regions of California contain seedborne *V. dahliae*. Currently, the negative economic impacts of Verticillium wilt on lettuce are mostly felt in the local region, but attempts to limit new introductions may have international trade implications for the seed industry.

Genetic evidence shows that spinach seed is the primary mode of introducing the *V. dahliae* pathogen into lettuce production fields. Analyses of the fungus from both lettuce and spinach have demonstrated that there is little differentiation between them. Additional tests have also shown that the fungus from spinach causes Verticillium wilt on lettuce.

The disease is appearing increasingly in the southern end of the Salinas Valley, where most of the current spinach production occurs, providing further circumstantial evidence that the fungus introduced from spinach is the cause of the disease in lettuce. Figure 3 shows the increase in spinach production in Monterey County, where Verticillium wilt is a problem, compared to the relatively stable level of spinach production in Santa Barbara County, where the disease has not appeared. Although historically the increase in spinach is linked to the increase in Verticillium wilt on lettuce, spinach production has declined in Monterey county since the E. coli outbreak in 2006.

Possible Solutions

Lettuce growers may not suspect that their crops are going to be affected by this disease until just weeks before the harvest when symptoms appear—at which point most inputs have already been applied. Growers may recoup some of their costs by harvesting early, but if Verticillium wilt is too widespread in the field, handlers may refuse to accept the lettuce. Even if it can be harvested and sold, the weight of the crop will be diminished. There are no treatments for Verticillium wilt after the plants have become contaminated. Early harvest is more of a stopgap measure than a true solution.

The profit margin on lettuce is sufficiently small so soil fumigation of the lettuce fields is not economically feasible. In addition, due to restrictions on methyl bromide use, the most common and effective fumigant for *V. dahliae*, land planted to lettuce is typically not directly fumigated.

Instead, some growers fumigate with methyl bromide, plant to strawberries, and rely on the residual effect to protect two to three subsequent crops of lettuce. This method does not eliminate the pathogen, but temporarily suppresses it.

Furthermore, the decrease in Critical Use Exemptions for methyl bromide under the Montreal Protocol makes this an unlikely long-term solution. Critical Use Exemptions are granted when "there are no other technically or economically feasible alternatives or substitutes available" to treat crops and the lack of availability would result in significant market disruption.

Other fungicides to treat lettuce fields directly to control other diseases are usually applied though irrigation drip tape. However, with this method, the entire field is not thoroughly treated and, thus, is less effective on diseases for which they are used but have little or no effect on Verticillium wilt. Organic producers are especially vulnerable because they cannot use any of these chemical treatment methods.

Because such a wide variety of crops, and even weeds, can be hosts to *V. dahliae*, crop rotation is not a complete solution. However, planting to broccoli reduces the incidence of Verticillium wilt on a subsequent lettuce crop on the same field.

Table 1. Value per Acre for California Crops				
	Lettuce	Broccoli	Spinach	Strawberries
Value ($ per Acre)	7,908	5,809	6,974	43,955

Note: Average value for years 2008-2010.
Source: California Agricultural Statistics: 2010 Crop Year. USDA NASS. www.cdfa.ca.gov/Statistics/

Table 1 shows the value per acre for the relevant crops in California. Broccoli is a low-margin crop and in the prime production areas of Monterey and Santa Cruz counties, it is not economically feasible to grow, unless one accounts for the side benefits of reducing the incidence of Verticillium wilt. Most broccoli is grown in the Central Valley and Imperial County where land costs are lower. Unfortunately, if all fields affected by the pathogen were planted to broccoli with enough frequency to reduce the disease, the broccoli market would be flooded, making an already marginally profitable crop even less so.

Resistant varieties of lettuce may be part of a policy to treat Verticillium wilt, but due to the evolution of the pathogen, this is unlikely to solve the problem completely. The USDA, along with the UC Davis breeding program, does the preliminary work to develop resistant varieties and then releases the work to private companies who further develop them into commercial cultivars.

There are two races, or types, of *V. dahliae* that affect lettuce. A variety resistant to race one should be available in the next year or two. However, growers will likely face increased costs to purchase these seeds. More problematic is the evolution of the pathogen. As more growers plant the variety resistant to race one, this selects for race two, i.e., encourages the spread of race two relative to race one. New varieties resistant to race two have not been identified at this time.

Although the actions described above may play a role in reducing the impact of *V. dahliae*, the most promising policy is seed testing, treatment and, perhaps, quarantine. A similar policy exists in Monterey County for Lettuce Mosaic Virus (LMV), which is also a seed-borne disease. No lettuce seed may be planted in the county without having first been "indexed," or tested, to have no more than zero infected seeds in a batch of 30,000. Implementing a similar policy for *V. dahliae* would require testing spinach seeds, rather than only lettuce seeds.

The indirect nature of the *V. dahliae* contamination complicates measuring the costs and benefits of a quarantine policy. A major issue is who pays for the seed testing—seed companies, lettuce growers, or spinach growers. Another part of this policy could require seed treatment for seeds which do not pass inspection.

Researchers are developing seed treatment protocols to reduce the introduction of the pathogen. If approved for organic growers, seed cleaning would be one of the few treatment options available to them. However, the issue remains—spinach growers, lettuce growers, and seed companies disagree on who should be responsible for the cost of these measures.

Current and Future Research

Verticillium wilt is likely to become increasingly important if current trends continue. Spinach production is likely to remain important to Monterey and Santa Cruz counties, so the number of infected fields is likely to continue increasing. The tightening of restrictions on methyl bromide use reduces the current and most direct solution. Given these facts, it is a critical time to study the impacts of the disease on the production of lettuce and related crops to recommend appropriate policy responses for the Verticillium wilt problem.

Goals of ongoing work include: characterizing populations of the fungus *V. dahliae*, determining the impact of the seed trade on Verticillium wilt, and studying sources of resistance and seed treatments for both conventional and organic growers. Learning more about each of these areas will allow for more effective and thorough economic analysis of Verticillium wilt, such as its cost on the leafy greens industry, the policy options available to mitigate these costs, and the international trade implications.

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For additional information, the authors recommend:

Atallah, Z.K., Ryan J. Hayes, and K.V. Subbarao. "Fifteen Years of Verticillium Wilt of Lettuce in America's Salad Bowl: A Tale of Immigration, Subjugation, and Abatement." *Plant Disease* 95(2011): 784-792.

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